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THE ANNUAL CONFERENCE ON HIGHWAY ENGINEERING

The Conference on Highway Engineering is held annually during the latter part of February or the beginning of March by the Department of Civil Engineering of the University of Illinois with the coöperation of the Illinois Division of Highways and the Illinois Association of County Superintendents of Highways.

It was started in 1914 under the name of the Short Course in Highway Engineering as a two-weeks training school for the newly-created County Superintendents of Highways. Since then its character has been changed from time to time to meet the ever-changing conditions of road building and administration in the state. In 1935 the present name was adopted.

Throughout the years the object has been to provide an opportunity for the highway builders and administrators of the state to get together for mutual acquaintance, to discuss the many problems that confront them, and to gain the latest and best information pertinent to their work. The results have demonstrated the value of the meeting, not only to those attending, but to the communities or interests they represent.

The Conference is open without fee to anyone interested in any way with improving the roads and streets of the state. The normal attendance consists of state, county, city, and local engineers and officials, road and street contractors, material and equipment dealers, and many others.

CONFERENCE ADMINISTRATION 1937

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I. PARKS AND HIGHWAYS IN STATE PLANNING

H. L. Kellogg*

Long before state planning was a recognized term, specialized planning work was done as a part of various and continuing governmental activities looking forward to a better economic use of natural resources and the greater development of facilities for happier and fuller living. It is well known, for instance, that the problems of combating illiteracy and providing educational facilities were a primary consideration in the early colonies and a definite administrative function of colonial government. The solution of this problem has ever since remained a state function. Our public school system, our state universities and agricultural colleges, are evidence in support of this fact.

Similarly, state conservation commissions grew out of a movement to preserve scenic and historic sites, and they became active as such about 1890. State planning in that field started with the organization of the "Trustees of Public Reservation," in Massachusetts, and the "Scenic and Historic Preservation Society," in New York, although a definite movement for the creation of state parks began about 60 or 70 years ago. It developed slowly, however, and, in fact, did not gain real momentum until approximately 15 years ago. Nevertheless, the foundations were laid in those days for such national monuments as the Yosemite National Park and the Niagara Falls Reservation. Twenty years later, the State of New York set aside two million acres as forest preserves, thereby gaining the distinction of being the first state in the Union to give official recognition to the need for conservation of its natural resources.

Concerned primarily with the establishment of individual and usually unrelated areas, earlier activities in state park planning gave little attention to a comprehensive arrangement of these natural beauty spots into an organized system. Much of the credit for the present comprehensive planning for state-wide park systems is due to the pioneer work of such men as Charles Eliot, John Nolen, and Frederick Law Olmsted, who developed a policy of planning, which, in its essential form, has since been adopted and successfully followed by many of our states.

Valuable as these early governmental activities were, they lost a great deal of their effectiveness because of lack of an agency that could

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properly correlate and coördinate them. While it is true that individual executives of vision and force have set up procedures designed to conserve natural resources for economic uses, and that many governmental and private institutions and departments conducted important researches and prepared valuable records, there has been little coördinated effort, until recently, to combine this individual research of many agencies into a general, well-rounded-out program for the comprehensive development of our facilities for a finer life and for the conservation and effective use of our resources. The present activity in the field of state planning is an effort to meet this need for coördination of the forward-looking research activities of our governmental agencies.

We are accustomed to think of planning as having to do only with ideas for physical developments which can be shown on a map or a diagram. This is generally true in local planning, but much less so when planning is applied on a state-wide basis. In that case, the approach to a state plan will probably take the form of a statement of present conditions in the various fields that are of general concern to our people and will result in a series of recommendations as to what should be done under the circumstances.

Therefore, in planning for a state-wide system of parks, the questions confronting the planner are obviously: "What is its purpose?" and "What is the best mode of procedure to create it?"

Unquestionably, its purpose is two fold: educational, due to its historical interest, and recreational, since it brings to the visitor the natural beauty or the unusual scenic characteristics of the state. A comprehensive system of state parks represents a typical portion of the state's original domain, offering much to all classes of citizens. To the city dweller these parks bring enjoyment of quiet and solitude, to rural people the pleasure of happy crowds and the opportunity of communion with strangers. Parks, with their flora, their geological structures, their beauty, their opportunity for clean and healthy sport, attract young and old, student, artist, and business man alike, since nature gives to each who comes that which he wishes.

The historic-political and the cultural development of Illinois covers a comparatively short span of time—less than a century and a quarter in fact. But the magnificent work of the intrepid explorers and early settlers who expanded the growth of the new world into the great middle west is well worthy of preservation for posterity. Persons interested in geology will find in the rock formations of the state, its canyons and gorges, its caves and palisades, an abundance of material for study. Lovers of plant life will find deep ravines filled with ferns and cliffs covered with rare and interesting flowering plants, shrubs, and vines; and the numerous Indian mounds, yielding arrowheads and pottery, tell the story of a long-continued Indian occupation of the territory.

The value of recreational facilities offered by a state-wide park system for the physical, mental, and moral well-being of citizens is still only partially realized. The increase of leisure time for both adults and children indicates the necessity for adequate recreational facilities with which much of this time should be occupied.

To open up such recreational facilities as a part of a state-wide system of parks requires, of course, a discriminating search for suitable sites, their acquisition for the purposes indicated, and the development of ways and means to preserve them and to make them available for, and accessible to, the people of the state.

Recognition of the necessity for park areas in Illinois has been of slow growth and on an intensive scale only during the last few years. Until the adoption of the Civil Administrative Code in 1917, the parks owned by the state were unimportant and were administered by a commission which scattered its efforts. Today, however, the Division of Parks which is a part of the Department of Public Works and Buildings, and functions in coöperation with a Board of Park Advisors, can point to 34 state parks and memorials, covering over 10 000 acres.

This agency, clearly viewing the need of withholding from commercial exploitation and probably ultimate destruction a maximum of unspoiled lands of historic, scientific, or recreational significance, and waters sufficient to meet the present and predictable future recreational needs of the people, developed a set of principles which were to control the selection of areas to be used for park purposes and thereby to prevent loading up the system with a collection of sites without definite relevant values.

These principles were enacted as laws by the legislature and, in their entirety, established a policy which seeks to achieve four major objectives:

(1) To preserve and mark the most important historic sites and events which are connected with early pioneer or Indian history. It is essential that the history of the explorers, missionaries, and settlers be preserved, not only as a tribute to those who made possible the building of the State of Illinois and of the Union, but as part of the education of future Illinois citizens.

(2) To set aside as public reservations those locations which have

unusual scenic attractions caused by geologic or topographic formations, such as canyons, gorges, caves, dunes, beaches, moraines, palisades, examples of Illinois prairie, and points of scientific interest to botanists and naturalists. These areas should be large in size, preferably not less than 1000 acres in extent.

(3) To preserve large forested areas and marginal lands along the rivers, small water courses, and lakes for a recreational use different from that given by the typical city park, and so that these tracts may remain unchanged by civilization, so far as possible, and be kept for future generations. Such areas also should be acquired in units of 1000 acres or more, and may be available as fish and game preserves.

(4) To connect these parks with each other by a system of scenic parkways with widths varying from 100 to 1000 feet, as a supplement to and completion of the state highway system. Where the present state highway routes may serve this purpose, their location, alignment, and design should be studied with this plan in view. At suitable locations along these parkways, pure water supplies and shelters and comfort facilities of attractive design may be installed for the convenience of the public.

The pursuance of this planning policy will logically develop a state park pattern largely along the major water courses of the state, and on the shores of Lake Michigan. In addition, there are, and will be, a number of special sites which, due to their topographic, geological, or historical significance, merit their addition to the system, although they are not located on one of the river courses. Other areas, suitable for state parks but not close to present population centers should nevertheless be included in a general acquisition plan, looking forward to a time when better transportation facilities and an increased population will make the need for them more urgent.

A detailed technical study of these needs indicates, for well-distributed municipal parks and playgrounds, 10 acres for each 1000 city people. Similarly, for state parks, 8 to 10 acres are found necessary for each 1000 of the total population.

Since one of the major objectives of parks is recreation, areas offering such facilities should be provided, at any reasonable cost. They should preferably be adjacent or accessible to present or future concentrations of population.

As outlined in the policy of land acquisition, the pattern of a state park system is dictated in some measure by the system of rivers, lakes, and small water courses which border and penetrate the state.

Along the Mississippi River, from the Wisconsin line to Cairo, there are bluffs, palisades, marsh lands, forested promontories, and historic sites which should be added, unit after unit, to the system.

The Ohio River on the south, and the Wabash River on the east boundaries of the state likewise have history and legend, forests, and unusual topographic features, which bring these areas definitely to the fore as potential parks and reserves.

Diagonally across the state, from the region of Chicago to the Mississippi River, is the DesPlaines-Fox-Kankakee-Illinois River system, rich in park sites which commemorate Indian and mound-builder history and the early exploration and settlement by Joliet, Marquette, Tonti, LaSalle, and their equally sturdy companions and successors. For this area, incidentally, there is planned the Missouri-Illinois Interstate Scenic Parkway, to be developed in coöperation with the National Park Service. This interstate parkway is designed to extend from Chicago along the DesPlaines and Illinois Rivers to Alton, where it crosses the Mississippi and runs thence along the National Forests and the Lake of the Ozarks to terminii at Kansas City and the proposed Table Rock Reservoir.

On Lake Michigan, there remains the last seven miles of beach and low sand dune country which has not been settled upon by industrial and other developments.

The Sangamon River, passing through the state capital, and other populated centers, has sites for potential parks or reserves which can be connected with each other both by water and by riverside driveways.

In the Kaskaskia River valley, in the valley of the Big Muddy River, and along the Little Wabash and the Embarrass Rivers in the southern part of the state, there are splendid sites for forests and fish and game reserves which will perfect the system of state recreation areas.

From the Wabash River, opposite Vincennes, along the Embarrass River into Coles County, thence across toward Springfield, New Salem, and Beardstown, is the route followed by Abraham Lincoln and his family in their westward movement from Kentucky and Indiana. All available records should be checked to permit the careful tracing of this route and the development of unit after unit of a parkway connecting known parts of historic interest related to Lincoln.

There are four distinct methods of obtaining lands for state parks, i.e. by purchase, by gift, by condemnation, or by transfer of public-owned lands.

Under normal conditions, purchase is the method by which park land will generally be obtained. During the recent years, however, financial difficulties have prevented any large appropriations for this purpose.

Transfers of property by gift or bequest have been numerous in the past. The adoption of a definite and comprehensive plan for a system of state parks, and the perfection of a continuing and able administrative force to carry out the plan has been a most effective means for encouraging and bringing about the gift of suitable park sites.

Condemnation should be resorted to only when it is apparent that a property is an essential part of the system, and when the owners cannot agree with the State on its value, or when titles to land are so clouded that court action is necessary to clear them.

A method which has great possibilities is that followed in a number of states, whereby public lands which were obtained for other uses which are no longer in effect, are assembled and transferred to the State Park Department. In particular, in Illinois there are canal lands and reserves, properties bordering upon the Illinois Waterway, etc., many of which can easily be made available for park purpose at very small expense.

A definite policy has been adopted, and should be maintained to keep Illinois state parks free from artificiality. Fundamentally, our state parks should always remain truly historical or naturalistic in character, so that they may accurately interpret the broad aspects of Illinois historical development by means of a series of significant sites and areas.

The development of a state-wide park system would be of questionable value without the parallel development of a system of highways to make them easily accessible to everyone. Illinois has created such a basic highway system in the brief period of twelve years, having developed from its approximately 100 000 miles of dirt roads which were passable after a dry spell, but impassable, except on horseback, for much of each year, a network of highways which stands unchallenged among the states.

Following a basic plan evolved after a great amount of study and experimentation, an Illinois highway program was developed, adequately legislated and financed, and carried out. While it may be true that some parts of this system might have been improved, subsequent traffic analysis has demonstrated that it was so located and distributed as to serve well the great bulk of the traffic offered.

Obviously, there can be neither pause nor retrogression in the development of a perfect highway system for the state, and the Commission on Future Road Program, appointed by the 57th General

Assembly, embodied in its report of 1933 certain recommendations tending to establish "a future road program which is rational, equitable and worthy of Illinois."

Specifically, it recommends that:

"Needed refinements on the original state bond issue system, such as grade separations, large river bridges, corrections of location and alignment of some older roads, resurfacing and widening in accordance with traffic needs, should be completed as funds become available."

Insofar as future extensions of the state system may be needed, they should be added through the paving of highways of the state-aid system in the individual counties.

The Commission recommends that:

"The State should continue to construct and maintain extensions of state bond issue and Federal aid roads in all municipalities, but without restriction as to type and width of improvement. Funds appropriated to the Department of Public Works and Buildings for this purpose shall be allotted to all municipalities on the basis of their population. When such funds are not needed on such road extensions they should be used on a system of arterial streets or boulevards selected by the municipality with the approval of the Department of Public Works and Buildings."

In part, this recommendation has been enacted into law and is now in operation.

The need for the improvement of local rural highways has long been realized, but cost of materials, difficulty of selection, and other local problems have delayed the execution of construction programs except in highly developed areas. An extensive program of rural highway improvement has been instituted by C.W.A., I.E.R.C., and W.P.A. The State Highway Division, in coöperation with the U.S. Bureau of Public Roads, is now making a thorough survey of the situation. A report on the status of the survey will no doubt be presented at this meeting.

In general, it may be said that planning for either park or highway development requires a careful analysis of all data available as well in their specific fields as in those collateral to them. From a study of these data, and of the appropriations available, the logical programs of actual performance may be worked out.

II. PROGRESS ON THE STATE-WIDE HIGHWAY PLANNING SURVEY IN ILLINOIS

F. N. BARKER*

Before discussing the progress of the State-Wide Highway Planning Survey in Illinois, it is in order to describe the need for such a survey and to trace the circumstances which have caused the state to undertake the tremendous amount of work involved in such a study. This paper will also outline the objectives of the survey and the methods being used to attain these objectives.

Road development in this as well as other states parallels very closely the development of motor transportation. In the early days of road building, traffic needs were easily seen and the problem of road location was comparatively simple. The important thing in those days was the provision of transportation facilities between county seats and the larger municipalities within the state. The relatively small mileage of roads which was necessary to provide the most direct inter-city connections would obviously serve the major portion of traffic movement, and these roads were selected to form the state primary and federal aid systems of highways.

Construction of the primary system to a standard consistent with the immediate needs of traffic proceeded at a rate governed principally by the funds available, and although this primary system of highways is now practically complete, in many ways the existing facilities are inadequate. It is an unfortunate paradox that the roads of greatest traffic importance were the first to be improved and, for this reason, are today the least adequate to meet the needs of modern motor traffic. This is occasioned in a large degree by unpredictable changes in motor vehicle design and performance—principally increases in speed capacities of passenger automobiles. It is now generally admitted that the primary system is not complete but must be subjected to constant and well planned refinement, modernization and expansion.

During the period of rapid construction of the primary system, the secondary and local roads, which consist mainly of roads of lesser traffic importance, were improved in varying degrees under the administration of the counties or local governmental units. Little accurate information has been available concerning the system of secondary roads in this state. In some cases the degree of improvement effected compares favorably with that of roads contained in the primary sys-

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tem, and in some instances this high degree of improvement is undoubtedly warranted. The major portion of this mileage of local roads, however, has been improved to a lower standard than that of the primary system, but whether or not the present degree of improvement provides completely satisfactory traffic service and how much and what part of the whole merits further improvement are questions that cannot be answered. No data have been available whereby these roads could be compared either by physical characteristics of improvement or by traffic importance. It is reasonable to believe that in general the roads of greater traffic importance have received a higher degree of improvement, but it is impossible to deny or comply with the insistent public demand for an extension of improvement to local service roads without adequate and precise knowledge of the extent, condition and comparative utility of roads contained in the secondary system.

I make no apology for the partial obsolescence of the primary system or the general unsatisfactory condition of local service roads. Certainly no one conversant with modern highway problems would claim that our primary system of roads as it now exists is either entirely satisfactory or completely adequate for present day traffic needs. The high rate of accident occurrence on our primary highways has received considerable publicity recently, and, while a large number of accidents would undoubtedly occur even if highway facilities were perfect, it is nevertheless quite certain that many highway accidents are caused by the inadequacy or obsolescence of our present pavements. If for no other reason than to reduce accident occurrence, the primary system of roads should be subjected to an intelligent and comprehensive program of improvement. Likewise, it is certain that the program of improvement should include portions of the secondary and local roads, which comprise approximately 70 per cent of our total road system.

Admitting the deficiencies of the present highway system, the construction of this system has answered the demand of the motoring public for a comprehensive system of all-weather roads. In combination with like improvements in other states, it has encouraged automobile manufacturers to perfect their products and the people to buy them until the automobile has become a business and recreational necessity. It has facilitated the movement of agricultural products to the extent that a natural redistribution of rural population is in progress and it has allowed traffic to develop in a natural manner and along the channels which it desires to use.

The road system has now reached a state of completion where it will serve the immediate needs of the motoring public. The automobile is approaching its ultimate development and future road speeds and traffic trends may be forecast with reasonable accuracy even though the previous lack of coöperation between the automobile manufacturer and the highway engineer continues. Construction and maintenance costs of various types of improvement are available for comparisons and for making future estimates of the extent of the highway system which may be supported by available incomes for road purposes.

We have, accordingly, realized the fact that the early or pioneer period of road building is past, that a new stage in the development of highways and highway transportation is at hand, and that policies and standards developed during the pioneer stage require modification to fit new conditions. Transportation problems which were comparatively simple in the pioneer stage of development have become more complex and their solution requires accurate data and a complete understanding of highway problems.

The general idea of highway planning is not new. Highway engineers have long recognized the fact that a rational planning of the highway program is an engineering and economic necessity and some planning studies have previously been made. It remained for the Federal government, however, acting through its Bureau of Public Roads, to perfect and promote a plan for a complete highway planning survey. The fact that forty states are now engaged in the course of investigation suggested by the Bureau indicates that the need for such a survey was generally recognized.

Contained in the Hayden-Cartwright Act of 1934 was the first recognition in Federal highway legislation of the need for a definite plan of future highway improvements extending beyond the main roads. This act reads in part: "With the approval of the Secretary of Agriculture, not to exceed one and one-half percentum of the amount appropriated for any year to any state under sections 1 and 4 of this act may be used for surveys, plans and engineering investigations for future construction in such state, either on the federal highway system and extensions thereof, or on secondary or feeder roads."

The Division of Highways welcomed the proposal of the Bureau of Public Roads made in September, 1935, that the State of Illinois undertake a survey along lines of the Bureau's plan to develop accurate information concerning the road system of the entire state, utilizing for that purpose funds authorized by the Hayden-Cartwright Act. In undertaking this survey, officially designated as the State-Wide Highway Planning Survey, the Division of Highways recognized the fact that the once simple problem of highway planning and improvement had become more complex and that the future improvement program should be based on uncontestable and absolute facts rather than upon conflicting and biased opinions.

The essentials of a complete highway planning survey, as described by the Bureau, consisted of various inter-related studies of physical and operating conditions of all roads comprising the highway system. Included in the plan are comprehensive studies of the personal and commercial use of the several classes of roads, studies of the present and estimate of probable future financial resources of the state which are or will be available for sustaining the maximum highway investment, and investigations to determine the status of ownership of motor vehicles, distribution of rural population and classifications of agricultural lands. The field work to be performed in connection with these various studies consists of several separate operations and these operations will be discussed separately, although it should be understood that, in the analysis of the survey data, results of these various investigations will be correlated and interpreted so as to present a complete picture of the highway problem.

The organization of the survey and methods used by the various field parties have previously been explained by Mr. Charles E. DeLeuw in a paper presented before this conference in February, 1936, and these details will be described here only briefly.

Rural Road Inventory

By means of the road inventory, we have for the first time determined by actual measurement the exact extent of our highway facilities and, in detail, their present condition. The location of all farmhouses, churches, schools, business establishments, mines and other places that are the origin or destination of highway traffic have been recorded. Detailed studies have been made of railroad grade crossings and bridges. On the primary roads any existing inadequate conditions of sight distance, curvature and grade that limit the service value of these roads have been located and described.

Road inventory field work was initiated on November 7, 1935, and was completed by July 11, 1936. This phase of the work was supervised directly by the ten highway districts into which the state is divided. During the course of the work, 106 963.6 miles of rural roads were inventoried by the field parties, this work requiring these parties to drive a total of 294 718 miles. The winter of 1935-1936 was unusually severe for this state and the progress of the road inventory parties was delayed considerably by the rigorous weather and unfavorable road conditions. Over the entire state, the rate of progress of the inventory parties averaged 28.3 miles per party per day, and varied from 18.7 miles per party per day in Cook County to 36.2 miles per party per day in the northwestern part of the state.

At the end of 1935 the total mileage of public highways in Illinois was estimated at 97 615 miles. The figure of 106 963.6 given as the mileage inventoried by the field parties, while subject to correction due to the fact that during the early part of the survey field parties included in their inventory streets of subdivisions outside of municipalities, nevertheless indicates that the figure previously used was too low. It is quite certain that the final figure developed will exceed 100 000 miles.

The original plan for road inventory did not include any work inside of municipalities except the logging of distances to connect important rural roads with some marked route or easily-defined point within the municipality. It was considered that an inventory of important streets in municipalities would be of value to the Division of Highways, and the approval of the Bureau of Public Roads for the expansion of the road inventory to include extensions to U.S., S.B.I. and S.A. routes in municipalities was secured in May, 1936. Due to the fact that the rural road inventory was completed in the majority of the counties in the state by that time, it was necessary to organize special parties and complete the municipal inventory as a separate operation.

The municipal inventory secured detailed information relative to physical characteristics of streets, including many details not recorded for rural roads. Where available, construction data were secured for all streets, and the general type of development along both sides of the street was noted as residential, commercial, industrial, undeveloped, etc. In the course of the work, a total of 3256 miles of city streets were inventoried at an average rate of 5.4 miles per party per day. Work on this phase was started June 15 and was completed in all municipalities in the state, with the exception of the City of Chicago, by December 22, 1936.

Another phase of the road inventory was an investigation to determine the points on the primary system where clear sight distances were restricted by reason of vertical or horizontal curvature, or by some obstruction, to distances of 1000 feet or less. It was possible, by an inspection of the construction plans on file in the district offices, to determine points of sight restriction due to vertical curvature, and also to determine points of possible restriction of sight due to horizontal curvature. All of the plans for construction sections on the primary system have been investigated and restricted sights due to vertical curvature grouped in two classifications, i.e., clear sight of 500 to 1000 feet, and clear sight of less than 500 feet. At the same time all locations were noted where sight distances might be restricted to 1000 feet or less due to horizontal curvature. Field parties then investigated these questionable locations and all points where sight was found to be restricted to 1000 feet or less were grouped under the same two classifications. This investigation is now practically complete.

In November, 1936, the Bureau of Public Roads proposed an expansion of the railroad grade crossing study. The plan for this work necessitated that the various railroad operating companies furnish the planning survey with information regarding train movements over each grade crossing, including data on crossings which may be blocked by standing trains or switching movements, the characteristics of train movements as of high speed or ordinary speed and a detailed record of all accidents that have occurred at the various crossings during the period of the preceding five years. This information is being furnished by the railroad companies and will be correlated with data from the railroad crossing investigation made by the highway planning survey. It is proposed that an order of priority in grade crossing elimination then be established based on factors of hazard and potential traffic delay.

The field notes of the road inventory parties are being plotted on county maps of the state, these maps being prepared to the scale of one mile to the inch. A surprisingly large number of errors have been found in road locations as shown on our available county maps. In addition, corrections are being made for locations of railroads, streams, corporate limits of municipalities, and any other features of the map found to be in error. The surface type of all roads and the location of all buildings and places of public congregation will be indicated on the maps by suitable conventions. Seventy-five county maps have been completed to date, with the exception of titles, legends and cultural features, and maps for all of the one hundred and two counties in the state will probably be completed by early summer.

A state map will be developed and drawn to the scale of eight miles to the inch somewhat along the lines of the present maps which are distributed by the Division of Highways. It is then proposed to show on both the county and state maps information regarding road surface types and public transportation routes such as common carrier and school bus routes, common carrier truck routes and rural mail routes.

The completion of this series of maps should provide an invaluable aid to future highway planning and also to public planning of any kind that requires an exact knowledge of the distribution of population and industry and the existing facilities of transportation.

If the greatest possible benefit is to be derived from the rural road inventory, a large number of tabulations of the data secured should be made. The completion of manual tabulations to include all of the information recorded by the field parties and combined in the large number of tables desired would be an overwhelming task. For this reason, it is proposed to complete these tabulations by machine methods, using either the Hollerith or Powers card forms and machines. The rural road inventory data will be placed on tabulating cards, and various tables compiled by combining these data in different ways. By use of these cards, any selected route or combination of routes may be analyzed by passing the cards through a sorting machine.

Codes for showing all the road inventory information on machine cards have been designed and coding of the field notes is approximately 70 per cent complete. Separate cards have been designed for the rural road inventory, the municipal inventory and the crossings inventory, which includes railroad grade crossings, grade separations, and bridges. The work of compiling the tabulations will be done by contract, inasmuch as the state does not have sufficient equipment of this nature to complete the work. No estimate of the time when these tabulations will be completed and available can be made.

Traffic Survey

In addition to the study of the present traffic use of each part of the entire road system, including state, county, and township roads, the traffic survey made by the State-Wide Highway Planning Survey included special studies of the types, dimensions and loading of commercial vehicles, classification of commodities carried, origin and destination of commodities carried on both main highways and local roads, and the operating classification of various commercial vehicles as private, contract, or common carrier.

For purpose of organization and source of funds, the traffic survey was divided into two separate operations, the continuous counts, on which samples of traffic were recorded at each station on several periods throughout the year, and the one day counts, which involved only one eight-hour operation at each station.

Three hundred and twenty-four key or continuous count stations were located throughout the state, most of them coinciding with control and base stations previously used by the state in making traffic surveys of the primary system. Of these 324 stations, 108 were selected as weighing stations, where commercial vehicles would be weighed on portable scales, and 216 were designated as density stations only. Schedules were designed and an organization perfected to extend the continuous count operations over the period of a year. This one year's schedule of operation was completed December 11, 1936, and, notwithstanding the severe weather conditions encountered in January and February of 1936, very few scheduled operations were missed either by the density recorders or by the weighing parties.

A total of 5794 eight-hour density counts were made by continuous count density recorders, and 1608 eight-hour weighing operations were completed by the scale parties. Approximately 125 000 commercial vehicles were weighed and classified by type of commodity carried, operating classification, and origin and destination.

To supplement the data secured by the weighing parties using portable scales, three pit scale stations consisting of permanent installations of platform scales of 30-ton capacity have been in operation since May, 1936. These three stations are located on important routes near the Chicago and East St. Louis areas which are known to carry a considerable amount of heavy commercial traffic. These stations are operated in rotation for a period of six weeks each. In addition to the axle and gross weights of vehicles, the pit scale party secures information regarding origin and destination, classification of commodity carried, operating classification of trucks and busses, and obtains measurements of the truck or bus dimensions. This operation is also scheduled for one year, and will continue until May, 1937.

Six automatic traffic recorders were installed in October, 1936, all of them being located on important routes of the primary system. These recorders operate on the photo-electric cell principle, so that vehicles are counted and automatically recorded for as long as the machine is in satisfactory operating condition. Accurate records from these machines will be of considerable value in coördinating the various traffic counts, and, if they are successful, the cost of securing continuous twenty-four hour density counts at the selected stations will be extremely low. The machines are still in an experimental stage, and their operation to date has not been entirely satisfactory.

A total of 22 000 one-day count stations were located throughout the state where at least one eight-hour traffic count was made. Approximately 300 of these stations were selected as control stations, and at these stations additional seasonal counts have been or will be made, one count being scheduled for each of the four seasons. All of these counts were scheduled for the daylight hours on week days, but at 150 of the control stations additional eight-hour counts on Saturday and Sunday and one eight-hour week-day night count have been made. Such control station counts, together with the data from the key stations, will give sufficient information for converting all eight-hour counts to twenty-four hour average traffic volumes under all of the existing conditions in the state. All counts at the one-day stations have been made by Works Progress Administration personnel, and the only work remaining is the spring and summer count at control stations.

The analysis of the traffic count will be completed by machine methods and it is proposed to compile tabulations of the data secured in a large number of combinations. It is also proposed to develop complete traffic maps indicating traffic volumes by band widths for all of the roads in the state. Very little work has been accomplished to date in analyzing the traffic data and the results of this survey will not be available for some time.

Economic Surveys

Road-Use Survey. The road-use survey as developed by the Bureau of Public Roads will determine the relative use of the primary, secondary, and local road systems of the state and of city streets by motor vehicle owners residing in rural areas and in urban places of various sizes. Data required for this study must be secured by personal interviews with representative motor vehicle drivers. Experience indicates that the pattern of an individual's driving throughout a year is such that a large portion of it can be accounted for in numerous habitual trips, regularly-driven random trips, or unusual and rare trips which are easily remembered. Information obtained from vehicle owners by survey interviewers determines the extent of the owner's travel during the preceding twelve month period, and the routes used in such travel by highway systems.

It is, of course, impossible to interview personally each motor vehicle owner in the State of Illinois and a sample of 35 000 interviews with representative motor vehicle owners will be taken. These interviews will be carefully distributed among various counties and occupational groups. Parties are now operating in three different locations in the state and approximately 3300 interviews had been completed on March 1.

Analysis of these data will provide two important factors in highway planning, the total amount of travel on various portions of the several highway systems, and the amount of travel performed on the various systems by vehicle owners residing in the several governmental jurisdictions. Final results of the survey will be so presented that comparisons of the use of the several classes of highways can be made. These results will also permit an estimate to be made of the total traffic carried by the roads and streets of the state as well as the relative amounts carried by the several systems. It will furnish also an estimate of the relation of that traffic and the individuals who subscribe to the various sources of revenue by which the road systems in the state are built and maintained.

Preliminary analysis of the road-use study will consist of summarizing the data obtained from the interviews on tabulating cards by means of which various tables and charts will be compiled. No work has been accomplished to date on this phase of the work.

Motor Vehicle Allocation Study. The motor vehicle allocation study was designed to supplement the road-use study by providing complete information on the number of motor vehicles in each county, classed by ages and by types; the registration fees paid by these various types of vehicles; the motor fuel tax paid by the same groups; the total annual mileage driven in Illinois by each group; the average motor fuel tax and registration fee paid per vehicle; the distribution of passenger cars and trucks by weight or capacity classes in the various rural and urban areas; and the average miles of travel per gallon of gasoline consumed by passenger cars in different weight classifications.

The motor vehicle allocation study has been in progress since May, 1936. During the course of the study, questionnaires were mailed to 375 000 passenger car owners, 96 000 truck and bus owners, and 17 000 owners of motorcycles and trailers, and the registration lists as published by the Secretary of State were analyzed. Practically all of the work preliminary to the actual analysis and tabulation of the results obtained has been completed by personnel furnished by the National Youth Administration at no cost to the survey except for necessary supervision and supplies. The actual work of sorting, tabulating, and analyzing the returned questionnaires will begin immediately, and it is proposed that all of the analysis be completed by manual sorting and tabulating. It is estimated that approximately four months will be required to complete the analysis of this study.

Financial Survey. The receipts and expenditures during 1935 of funds of all governmental bodies of the state will be analyzed during the course of the financial survey. Revenues will be classified according to source and expenditures according to object. The amount of revenues paid by various taxpaying groups will be compared with the benefits to these groups resulting from the expenditures, and an estimate made of the probable maximum financial support that will be available for future highway programs.

Unfortunately, centralized records of local and county finances do not exist in Illinois in the form desired for the survey and, for this reason, it is necessary that information concerning these finances be secured by personal visit to the county offices of the one hundred and two counties in the state, and by personal contact with the city officials in all municipalities of 5000 population or over. Data for the smaller cities, villages, and townships will be secured by questionnaire.

Field work on the financial survey was initiated on July 20, and suspended on November 1, 1936. During this period of operation, twenty-three counties and twenty-three county seats were visited and the necessary data on finances secured. The field work remaining to be done includes visits to seventy-nine county offices and county seat municipalities, forty-nine visits to municipalities of 5000 population or over, and the mailing of questionnaires to 952 municipalities of less than 5000 population and to 1435 townships. It is expected that field work will be resumed on the financial survey in the very near future and should be completed within three months.

In the analysis of the financial survey, the full magnitude of the present financial provision for road and street purposes will be revealed, as well as the existing relation between the sum of all highway revenues and expenditures and the grand total of all revenues and expenditures for all purposes. Because of the large number of taxing jurisdictions, neither of these basic facts is known, and, for the same reason, plus the inadequacy of many of the public records, their determination is difficult.

Pavement Life Study. During the period of highway development in Illinois a large mileage of pavements of various types has been constructed, but comparatively few miles of this total have been retired due to structural failure, relocation, obsolescence, or other reasons. Opinions as to the probable average life of the various designs of pavement vary widely. It is a generally accepted fact that all of the pavements now in use will have to be replaced sometime in the future, but if provisions are to be made for replacing this pavement, it is necessary that the probable average life of the various types be known.

The ultimate objectives of the pavement life study which is being made by the planning survey are the determination of the probable average service life and rates of retirement for each type of surface and the determination of the annual roadway costs for the several types. Accomplishment of the first objective requires that a summary of construction and retirements year by year be made. To reach the second objective, it is necessary to know the probable average life, the maintenance cost, the original construction cost, and the probable salvage value of the various types of pavements.

The pavement life study is being conducted in the Bureau of Audits of the Division of Highways at Springfield, Illinois, where all of the records being investigated during the course of this study are located. Forms have been designed on which will be placed by construction and maintenance sections all costs to date of either construction or maintenance on these portions of road. These cards will be continually revised so that it will be possible at any time to immediately determine any detail of construction or maintenance—either costs or methods.

The transcribing of the original construction and maintenance records to a form where they are ready to be placed on the permanent card is about 80 per cent complete. No work whatever has been accomplished to date on the tabulating of any data developed by this study and no work has been done toward obtaining the ultimate objective of this study, which is the forecast of probable pavement life. It is probable that, due to the small number of pavement retirements which have been made in Illinois, any forecast of pavement life must be withheld until sufficient retirements have been made to form a substantial basis for this forecast.

Summary

To intelligently operate any public utility requires intimate knowledge of the extent of the utility, its physical condition, the relative service performed by each part, present and probable future maintenance costs, and present and probable future trend of revenues. The Division of Highways is in the position of operator of a large system of public transportation facilities, and it is the direct objective of the State-Wide Highway Planning Survey to secure all information necessary for the intelligent operation and administration of this utility.

The road inventory will provide detailed information regarding the extent of the system and its present physical condition. The traffic and road-use surveys will indicate the relative service performed by all parts of the system, as well as the need for any expansion. The pavement life study will furnish figures for maintenance and replacement costs, while the financial investigations and motor vehicle allocation study, in combination with parts of the road-use survey, will determine which parts of the system provide a return on the investment, and the maximum extent of the highway system which anticipated revenues may be logically expected to maintain.

It should be apparent that, although the collection of field data relating to various phases of the survey are separate operations, these various studies are very closely related and each forms an important part in a complete picture. It should also be apparent that the tremendous amount of field data collected will require considerable time for analysis and assembly, and although all the data and results of the survey will ultimately be available for use in planning by any public organization, it will probably be several months before the final results will be available for distribution.

III. HIGHWAY LANDSCAPING

Albin Gries*

Highway planting on a large scale made its beginning in Illinois late in the fall of 1933. We began with the idea that trees, preferably elms, must be planted in rows; and that we should transplant our parks and gardens to the highways as a sort of a decoration.

We made a step forward the following year when we graduated to the use of a design which demanded an irregular, instead of a formal arrangement of trees. This conventional method of planting had major defects; it was artificial and monotonous, and it failed in its attempt to achieve the objective of roadside planting, that of making the highway a part of the surrounding countryside.

Today, we are getting away from the park or estate design after three full years of highway planting experience. They were three years of trial and error methods, and of collaboration and coöperation with highway engineers, and we added to our training as landscape architects a very necessary highway point of view. Thus the highway landscape designs not only provided for the requirements of beauty, but also came to provide for those of utility and safety of the highway operation and investment. Our early designs had added to neither utility nor safety, and sometimes they accomplished the reverse effect. Trees were often placed so close to the traveled pavement that they became a hazard to the moving traffic, and almost always in locations and in a manner to cause an increase in the costs of mowing and snow removal.

As we conformed more nearly to the highway requirements with every season's planting, we learned a great deal about roadside planting from many other sources, the best of which suggested that we look to the old country road for inspiration in highway landscape treatment. Our country roads are still naturally attractive. Unscarred by the necessities of modern highway construction, the trees and undergrowth of the woodlands and the grass and wild flowers of the prairies extend into the right-of-way. Nothing has been disturbed, and the roadside is still a part of the surrounding landscape. As such it contains all of the elements of beauty, and, in addition, it meets many of the requirements of the highway engineer from the maintenance point of view. There is no soil erosion to combat here, nor are there weeds to control by constant mowing.

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The modern highway with its raw clay cut and fill banks resulting from the construction necessary to keep it at a nearly level grade as it passes through the elevations and depressions of the terrain, does not now resemble this old country road. But it is to this road that we can look for suggestions in highway planting treatment, and that is the restoration of the natural growth to the highway just as that growth existed before the road was cut through. We can, by grading the roadside to blend it with the roll of the land and by covering it with native plants, return the roadside to its original condition of harmony and balance with nature, the much desired condition of stability.

We are now definitely turning to conservation, to the management of our land which is the highway right-of-way. Conservationists agree that the destructive dust storms of the western states are caused by the absence of trees and ground cover to hold the moisture in the ground and to prevent sweeping winds. The Federal Government is planting forest belts over these areas to correct this evil; and so in Illinois the Division of Highways is also indirectly preventing it from happening. When we consider that the highway right-of-way in this State consists of approximately 100 000 acres of land, we can believe that what we do to restore the roadside will have an appreciable similar effect on the state's soil production problem. Such an area planted with trees and ground cover to prevent rapid run-off during rains, to hold moisture in the soil between rains, to shelter insectivorous animals, and to break the velocity of drying winds, will surely play a great part in helping to keep our farms productive.

With the rapid spread of the idea of soil conservation, we have, in our planting program, taken an active interest in the problems of soil erosion control. This spring, in coöperation with the Soil Conservation Service of the Department of Agriculture and the United States Bureau of Public Roads, we will have experiments in soil erosion control in progress on 35 projects on the highways in various locations throughout the state. These 35 projects represent 15 miles of highway selected out of a total of 1150 miles which a preliminary survey showed were suited to the experiments and in need of special treatment. That is an indication of the extent of our erosion problem.

Farm property owners, who are not always especially interested in the scenic aspects of the roadside, have been somewhat dubious about the value of highway plantings. In this state, before we can undertake any planting on the roadside we must obtain the written permission from the owners of the adjacent land. Very often we have been forced to leave gaps in our planting because we could not get consent. Now, however, that the farmers begin to appreciate the conservation aspect of our work, there is definite indication that we may expect to encounter much less resistance on their part. We were encouraged last fall when we received permissions to largely fill out the planting on a 100-mile project planted in 1934, where refusals of permission had left gaps totalling about 40 per cent of the mileage.

With the completion of last fall's program, 2791 miles of roadside have been planted to shade and flowering trees in Illinois. I purposely do not say that they all have been landscaped, for the intent of the program from the beginning until the spring of 1936 was to establish only a skeleton planting of trees as quickly as possible, and to return later to add the finishing touches. This limitation imposed on the planters by the Department was perhaps an accidental foresight, but it has been amply justified. Now it will be possible, in the light of experience in actual highway planting, to return to them, not to add the finishing touches of park or estate landscape methods, but to complete their planting with the more defined principles and purposes of highway landscape design in mind.

The very newest highways have had much beauty built into them. They are on wide rights-of-way, their slopes are flat, and their ditches are almost imperceptible. Their alignment and earthwork make them appear as though there has been little disturbance of the right-of-way in their construction, and it is a simple problem for the landscape engineer to restore the vegetation and make the roadside fit the surrounding landscape.

On the older roads we shall continue to confine our planting to highways that are eighty feet wide or wider. Trees planted on a right-of-way of lesser width cannot be placed at a safe distance from the pavement unless they are eventually to come in conflict with the overhead wires of the utility companies. On wide rights-of-way, we reserve a strip eleven feet wide, running parallel and adjacent to the two property lines, on which only low-growing trees and underbrush are planted. Outside of this strip tall-growing trees may be planted so they will need practically no trimming by the linemen who must keep their wires clear. By the acquisition of wider rights-of-way not only will safety be added to the highways by the construction of flatter slopes and the elimination of deep ditches, but incidentally there will be provided necessary room to accommodate both the overhead wires and trees.

Ground cover, for the present, will be planted only on those banks which present the greatest problem of maintenance against their washing and sliding during rainfall, and those whose slopes already extend to the property line and which cannot be flattened. Other banks whose slopes can be made flatter, with rounded contours to blend the roadside with the roll of the adjacent land, will be planted after such corrective grading is done.

In addition to the planting of new material, we are very much concerned with the preservation of existing trees and shrubs. In this activity our greatest effort is in control of the trimming by the utility companies of trees which happen to be growing too near their wires. Permits are issued to do this trimming only after the contemplated work has been investigated in the field by the landscape engineer, who later passes on the manner in which it was done. In this way, we are gradually putting an end to the methods by which many of our large trees have been disfigured. In our efforts to preserve existing trees, it has seemed that we have not always had the coöperation of all of the utility companies. However, investigations of all apparent failures to coöperate have shown that, except in a very few flagrant cases, the trees had been damaged by uninstructed linemen. On the whole the utility companies' representatives are anxious to know better pruning methods which will permit trees to grow more nearly in their natural form, and at the same time keep them more permanently clear of their wires. It is a process of education, and perhaps the results will not be apparent as soon as we could wish.

Another activity of the landscape section is the maintenance which young plants require for two years after they have been planted. They must be watered, and the soil around them must be kept mulched during the dry season. They are constantly watched for insect and disease infestations which must be combated with spray the moment they appear. We are equipped to do all this, and every year we have been able to decrease our death rate to a point very near the normal expectancy, even in the successive years of drought which have accompanied every planting so far. That these plants will live and thrive is most important to our purpose, that to our modern and efficient highways they will add the beauty and stability of the old country road.

IV. THE BEAUTIFICATION OF CITY STREETS

FLORENCE B. ROBINSON*

What I have to say appears at first so obvious as to seem almost hackneyed. Yet a short walk through any town or city in America will reveal that these simple facts are seldom observed. It is truly amazing how few people really see their surroundings. But to those few there is indeed no question of the crying need for a comprehensive program of beautification for the streets of our cities, either large or small. American cities of all sizes are noted for the unlovely results of a too rapid growth, for the barren and desolate ugliness brought about by the work of man, by wilful neglect and careless destruction and unconsidered remodelling done to his environment. First there was natural beauty, then chaos, then ugliness supreme—that is the history of the average city; and then finally a slow and often intermittent attempt at reconstruction. But this attempt to re-introduce beauty into the environment of man cannot be a restoration of nature. Changed conditions limit the beauty that may be attained to those arrangements and designs suited to the restriction of use.

City streets differ from country highways both as to local conditions and matters of design. Decreased light and decreased air, drainage, increased heat reflections and absorption, impurities in air and soil, reduced food and moisture, set limitations upon the plants that may properly be used. The needs of traffic, present and future, restrict the arrangements. The dominance of buildings and the infinite variety of architecture impose the necessity for a unifying treatment of some sort. And just as in the country the designer seeks to blend the highway harmoniously into the natural scenery, so here the city streets must partake of the character of their surroundings. They are a formal expression of the life and movements of man—direct lines of suitable traffic flow. For such reasons the free and natural grouping of trees and plants, the rhythmic spacing found in nature is here unsuitable. The straight lines of paving and curb and walks and buildings must, for the sake of harmony be repeated in the arrangement of plants and features of other kinds. The use of rows of trees is forced by the dominance of straight lines. This is the solution of a definite problem in harmonious arrangement, the recognition of the formality of a city plan. With the pavement, these rows, the repetition of lines of trunk and branch, are often the only unifying element

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along the street. For the same reasons it is advisable to use on any one street trees of a single type with similar habits of growth. This gives a more unified and pleasing result along the lines of vision. Variety already exists, too much variety, no more is needed. The need is for unification, for more harmony. Thus, again, the planting units should be of sufficient length to count in the average vista seen by the human eye, i.e., not less than two blocks—say 800 to 1000 feet in extent—broken only at street intersections; and beyond the single vista only slight variation—at least the use of similar forms and textures and colors.

Such matters should be controlled by the city and not be subject to the vagaries of the individual citizen, and no additions or removals should be allowed without permit from some central authority. Moreover this authority should not be divided, but for the sake of efficiency should be effective over both construction and beautification. And, to avoid wholesale destruction of trees due to the inroads of insect or disease, it is well to vary the varieties used on different streets.

For the benefit of the street as a whole and its general appearance there is need for definite regulations and restrictions not only as to the trees along the streets, but also as to any planting between building line and building line. The type of plants, their distance from sidewalks and paving, their final growth, need to be considered from the standpoint of beauty and also for the safety of pedestrians and traffic. Shrubs in the parking strip and intermittent hedges of various heights and colors along the street cause an unpleasant spottiness of effect. High growing plants and hedges at corners are dangerous to traffic, and, unless duplicated on all four points, look unbalanced and out-of-scale. Shrubs between sidewalks and paving or too high hedges narrow the effect of the street and cramp the vista. These things need regulation. And again I repeat, uniformity related to the needs of traffic, the use of the street, and the general effect is indicated. City streets are not country highways in any sense and an attempt to create an illusion of a tangled coppice or a roadside jungle is a mistake in character. Planting close to the pavement creates hazards of life and traffic while increasing greatly the cost of maintenance.

Again, the width of streets and the ultimate spread of trees should be related—very wide-spreading trees being used on avenues and boulevards, and narrower trees on narrower and residential streets. Numerous reasons can be cited for careful choice in this regard, of which I will mention only one—the welfare of the tree, the effect on its appearance, growth and length of life. Not only should the tree be chosen with some regard for its ultimate growth, but it should be so spaced along the street that it will have proper room for development. I submit that 45 feet apart is far too close for trees that naturally spread 70 to 100 feet. Spaced thus, their life is shortened at least one-half, and their appearance is damaged by deforming effects of overcrowding. Regulations should be made and enforced, based on research into this matter of growth. No tree can be beautiful that is not sound and healthy.

No tree on a city street has ever again as good a chance at perfection as it had before it was placed there. The requirements of a *good* street tree are exacting. I should like to call them to your attention, and I truly believe anyone would do well to check any trees to be used against these requirements. A street tree should be

- (a) entirely hardy
- (b) longlived
- (c) not too slow of growth
- (d) strong of fiber, not brittle nor given to breaking in storms
- (e) tolerant to smoke and soot and dust and gases
- (f) neat, not messy in habits—not dropping a constant litter
- (g) clean and free from insect and disease
- (h) of a height and spread suited to the width of the street
- (k) high branching
- (l) of a kind having a tough and firm bark, not easily bruised or damaged
- (m) of a kind giving a good shade, but not so dense that it keeps walks and pavements wet beneath it
- (n) of a kind having a good, compact and restricted root system, or one capable of being restrained
- (o) able to exist with a minimum of food and moisture
- (p) of a kind having foliage that will wash clean in a rain
- (q) of good form and color and texture

As I said, these are exacting requirements. Only a few trees can meet them. A few more compensate for their deficiencies by some characteristic so superb that it outweighs their faults.

In this matter of the use of trees in cities we in America are still in the *village* stage of development. We still use *village* trees in a *village* manner. This is no reflection on the village, but rather on the city which does not recognize its limitations and act accordingly. As for shrubs, we choose them without regard to height, plant them without regard to size and shear them to hard and ugly mounds although we usually decry the topiary work of older countries. The result is that our cities have the benefit of shade and greenery only in their outlying districts. When we realize that the trees to be used in cities must be city trees, adapted to the conditions of city streets, and that, once planted, they must be given definite care, then and then only will trees be brought back into our city streets. And they will no longer lack the beauty of foliage, the play of light and shade, the suggestion of coolness, and the mystery of shadows mingled with sunspots. When we recognize that the beauty of shrubs lies chiefly in their form and texture we will choose them more carefully, and then respect their natural growth. We will understand that public plantings and private plantings differ in their requirements and upkeep, and that we may not always use the same plants therein.

Knowing these things, we can bring greater beauty to our city streets through a program designed to stimulate and to foster suitable plants in suitable arrangements. To this end we need a definite program for every community, a program that involves the choice and kind of trees and plants to be used, their spacing and arrangement, their regular inspection, followed by proper care, and certain regulations and restrictions enforced upon the property owners and others who may have to do with the street planting.

V. THE UNIVERSITY AND HIGHWAY RESEARCH

M. L. Enger*

The College of Engineering of the University of Illinois has demonstrated an interest in the development of the highways of the State by sponsoring Highway Short Courses and Conferences. This is the Twenty-fourth Annual Highway Conference, and we hope to have the privilege of acting as your hosts for many years to come.

Since the organization of the Engineering Experiment Station in 1903, many studies and investigations of interest to highway engineers have been made and reported in publications of the Station. These include most of the investigations on concrete and reinforced concrete which have been in progress since the Station was organized, tests on culvert pipe, and three circulars on earth roads.

An investigation of arch bridges, in coöperation with the United States Bureau of Public Roads and the American Society of Civil Engineers, has been completed by Professor W. M. Wilson. The paper giving the results of the investigation won for Professor Wilson the J. James R. Croes Medal of the American Society of Civil Engineers.

An investigation of reinforced concrete bridge slabs in coöperation with the Illinois Division of Highways and the United States Bureau of Public Roads has been under way since September 1936, under the direction of Professor F. E. Richart. Excellent progress has been made in the mathematical analyses of this very important and complicated problem. It is expected that the laboratory investigation will begin within a few months.

An investigation of the properties of Chicago region dolomites in coöperation with the Illinois Division of Highways and the State Geological Survey Division has been started recently.

An investigation of rigid frame bridges in coöperation with the Portland Cement Association, under the direction of Professor Wilson, has been under way for some time.

In addition to the researches under formal coöperative agreements a number of research projects have been carried on by members of the teaching staff. Professor Wiley has been investigating the possibility of improving highway signs and license plates, has been making studies of the effect of stop and go lights on traffic movement, and the relation of through traffic to local traffic in Champaign-Urbana. Professor Crandell has been investigating bitumens, especially the proper-

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ties resulting from combinations with other materials, and recently spent six months studying highway design and construction in Europe.

The Engineering Experiment Station has unusually good facilities for highway research, such as an excellent library, many well-equipped laboratories, a trained research staff, and specialists in many fields available for advice and consultation. The University stands ready to assist the Division of Highways within the limits of its facilities and resources.

VI. COÖPERATION IN HIGHWAY RESEARCH

C. M. Hathaway*

In presenting this paper I propose to offer a few of my own ideas on coöperation as I see it from the viewpoint of the practising highway engineer, but I shall make no attempt to present any concrete scheme of action. I must admit that I have always been in a quandary as to why there was not closer coöperation between these two great state units—the University of Illinois and the Division of Highways—and for some time I have given much thought and study to the possible value and benefit to us both. Perhaps the answer for the past lies in the intervening one hundred miles which separate Springfield from Urbana, and the consequent lack of knowledge of the other's individual problems and activities.

First, and most logically, may I suggest a studied interchange of ideas and accomplishments of common interest to the two departments: that is, the State Division of Highways and the section of the University of Illinois comprising the Department of Civil Engineering, more especially Highway Engineering. I know that all departments of your engineering college, and especially the Engineering Experiment Station, carry on a vast amount of research and investigational work, and it is my opinion that the University has certain facilities, excellent equipment, rather ample funds (if you please), and man power, to carry on certain work which would be very costly and difficult for us to handle and, in fact, illogical to duplicate. I know that you publish from time to time valuable bulletins and have at hand for ready release complete reports of the research work of each department. On the other hand, anyone well acquainted with the completeness and background of our State highway laboratory, whose activities even antedate the Bates Road experiment, cannot help but realize the extensive investigational work which has been done—most of it closely checked by actual field practice. All of this experimental and research work is summarized or discussed in complete reports, all of which are in your Engineering Library. In addition to the laboratory work, the various bureaus—design, construction, maintenance, and audits—have correlated much practical information and established many policies governing the various classes of work comprising standard design, construction, and maintenance methods, organization, and cost data.

Bearing this in mind I am satisfied that, although we are carrying

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on research work for somewhat different purposes, yet we are both working to the same end—the University perhaps for the development of the theory, the State for practical application; yet we know that practice is based on theory, and that the results of practice determine whether or not the theory is sound.

I am happy to say that there *have* been a few coöperative measures carried on recently, yet I think that they are all too few, and that we are both duplicating work, to a large degree, when closer study might enable us to broaden out the scope of our several problems at no extra expense. Each might take its appropriate share of the study, with the elimination of unnecessary duplication.

Another outstanding feature recently noted is what the University may do by lecture courses, and I refer to the series of lectures given last year by Dr. Terzaghi. When these lectures were announced, Mr. Lieberman was very desirous that a goodly number of our older engineers attend them. From the continued comments and interest in foundations and soils which resulted, I know that a definite impression was left in the minds of all of our men, and that there has been instituted investigational work which will save us many dollars in the future. The University, I believe, has within it the facilities to draw on men of this type, whereas it would be very difficult and impracticable for the Division of Highways to do so.

Another very concrete example of coöperative work is that which we have carried on for a number of years with Dr. Leighton of the State Geological Survey. In making this reference, permit me to state that I know full well that the Geological Survey is not a department of the University, yet at the same time, due to its location, it is often so regarded. Nevertheless this coöperative work is one of the best examples of what has been and can be accomplished.

Dr. Leighton and Dr. Ekblaw have undertaken a rather complete field survey to determine the availability of road building materials such as gravel and broken stone, and their frequent field inspections in studying problems related to soil geology, earth slides, and the construction of fills, have been of inestimable value. As a result we have come to believe that there is really no need of a separate organization of this sort confined exclusively to the highway department. They have the proper setup for the work, and in our minds it might be even logical to urge a larger State appropriation to them in order that they may undertake some of our problems, rather than attempt the work with our own organization.

Let me now offer a few specific examples, illustrative to some degree of what I have in mind. A recent coöperative project was carried on at the Meredosia bridge by the bridge department and Professor Wilson. The Engineering Experiment Station, the Federal Bureau of Public Roads, and the Division of Highways are now engaged in a very comprehensive investigation of reinforced concrete bridge slabs to determine their behaviour under varying conditions. These examples illustrate how bridge design may be influenced by conclusions drawn from similar investigational work. On the other hand, the actual construction of the structure offers a chance to study practical results in the field, either in proving the correctness of the theory, or suggesting logical changes. At very little cost and very little inconvenience this department can arrange with the contractor to carry on a complete set of investigations during the construction of some specific bridge.

The department of highway engineering has recently established a course in soils, and has undertaken a considerable amount of laboratory work. This is a new subject which has come to the front very rapidly in the last few years, and which in my opinion is going to become of paramount significance in the highway field. Admittedly, from contact with other states, there is very little known and much to learn; therefore the close coöperation of our own organization with Professor Bauer is going to be well worth while.

Let me list now a few of our present problems under investigation:

There is some question as to just how much compaction of earth embankments is necessary, and the proper method of obtaining it. All soils may not require the same amount of compaction for equal service. The type of surfacing may alter the requirements of the embankments and subgrade. More practical field tests are needed for determining the density of the soil in place. Also, a simpler classification of soils for field use is desirable.

The action of gravitational and capillary water is very apparent in the destruction of pavements, and some means of eliminating it must be demonstrated.

The proper thickness for a gravel surface or a base is still a problem. We see some only two inches thick successfully carrying traffic, and others six inches thick which are failing. Evidently there are subgrade conditions which influence this factor more than thickness.

What is the future of the cement-earth road?

A study of the economics and adaptability of the various designs of bituminous mixes, surface treatments, retreads, cold lays, hot mixes and sheets, and the classification of bituminous materials offer an unlimited field for research. These types are of special interest in connection with resurfacing and on the secondary system.

Safety is affecting our whole design structure, and the development of adequate safety devices and signs is a study in itself.

These suggestions are intended only to point the way. Time will develop and produce other subjects which may well be undertaken, either on some coöperative plan, or by some method whereby the conclusions of one department become available to the other, thus checking theory and practice.

The last point which I shall discuss is unique in a way, and may cause a raising of the eyebrows of the faculty members as well as of the members of our own organization. Call it a hobby or "a dream," if you please, yet it is based on observing over a score of years the newly-graduated student develop as a highway engineer. The development of the practical side needs more attention in the college training of our young highway engineers, and I am frank to state that either the student is not getting all that he needs to meet the field problems of today, or we older highway engineers are not able to get it out of him after graduation. It might be well perhaps to recognize the fact that an extra year or two of engineering study would be necessary to specialize in some of the subjects which I believe need more attention.

The subject of soil studies is new, but the study of geology is old. Every day the field engineer demonstrates that his knowledge of soil geology is limited, yet in practical experience this is the one thing which he needs in dealing with bridge foundations and stream runoff, in determining the stability of embankments, in calculating earth pressures against abutments, in avoiding slides through deep cuts, and in the preparation of suitable subgrades for pavement.

Shortly after my own graduation I heard a prominent engineer state that in his opinion one of the best fields in engineering was that of the engineer-lawyer. My own experience leads me to state that the situation has changed little in twenty-five years. I don't mean that every resident engineer needs to be a lawyer, but every field engineer sooner or later has to present some controversial problem in a clean-cut concise manner, whereby the result is going to be determined by the real evidence which he can submit. All too frequently I am called upon to "sit in" as judge on controversial points, and many, many times I have become discouraged and even disgusted at the manner in which our own men prepare and present their evidence. In the back of their heads they know they are right, but apparently they can't present it in what is termed in law "actual evidence." They may be able to argue all right, but they show lack of knowledge of the basic rules of argumentation.

Another outstanding drawback is the inability of many of our engineers to write a clean-cut report, presenting all the facts concisely and conclusively. Time after time I must ask for additional information on some leading question, which is perfectly clear to the engineer writing the letter, but which is very vague or uncertain to the reader of the letter. More knowledge of contract law, highway auditing, and interpretation of specifications is needed by our young engineers.

Many of our men fail to realize that each job offers innumerable chances for investigational work and development of new ideas, and failing to appreciate this, they become lost in a realm of routine procedure. Shouldn't these subjects be stressed more?

It may not be such a long thought ahead to suggest that our engineers in their sophomore and junior vacations should be required to engage in the branch of engineering which they are studying through a coöperative plan between the University and the Division of Highways.

I see value in an arrangement for a series of lectures by members of the highway department and allied interests, which would embody the problems which the young highway engineer must encounter in his every day work, and I offer this suggestion because I feel that the Division of Highways has specialists who have been engaged in highway engineering for many years, and who have acquired a vast fund of knowledge in highway matters which might well be of some practical value to the student body.

There is another factor which influences this rather radical suggestion which I have just made, and that is that we in Illinois, as well as the rest of the country, are entering a road-building era more complicated than ever before. For the past twenty years we have been building highways on the primary system to connect important centers of population, both State and continental lines of traffic, whereby one may get from one place to another 365 days in the year. Questions of design, construction, and maintenance have been in the making. Although our primary system is nearly completed, we now find that speed, safety and intensity of traffic are still "a few jumps" ahead, and that the modernizing of many miles of old pavement must be considered at once, and in addition the secondary and farm-to-market roads (some 65 000 miles) are demanding immediate attention. A study of the economics of type and location, proper sequence of construction, and adequate financing, is already well under way. There is being developed today a horde of new ideas. Some of these are based on pure sales talk, and some on sound basic principles. By this I mean that the average engineer must guard himself today in adopting new methods and new types by deciding whether or not this new idea or type is founded on basic principles, or on a sales argument or local enthusiasm without rational background. We as engineers are confronted with this task daily; you, in preparing your young engineers, are bound to train them to meet the same situation. This is why a coöperation in research, and the introduction of several pertinent subjects in the training of engineers, seem so vitally necessary at this time; and if you please, let me conclude: if I have stirred up some dormant possibilities, let us develop them as rapidly as consistent with the common cause—highway engineering—theoretical and practical.

VII. SOIL-CEMENT ROAD PROJECT, WINNEBAGO COUNTY, ILLINOIS

V. L. Glover*

The details of constructing the experimental section near Rockford, Winnebago County, Illinois, will not be described, because it is assumed that the method of constructing soil-cement road surfaces is generally understood. In the construction of this project, however, the methods which had been developed to that time were followed as closely as possible.

It will be my intention to bring out certain things about the construction operations which logically might be criticised and which should be avoided in future construction of this kind.

Preliminary Samples.—The section was about 6000 feet in length and the surface was 18 feet in width. The soil type was predominantly sandy loam. The grading work had not been done at the time the samples, on which the preliminary work was based, were taken. It was thought that the soil in the existing roadway was sufficiently uniform so that tests based on samples taken from it would give satisfactory results, and the samples were taken accordingly.

The test data showed that 10 per cent of cement by volume should be added to the soil for the most satisfactory stabilization, that the optimum moisture contents should be 16 per cent, and that the weight per cubic foot of the finished compacted mixture should be 112 pounds.

Construction.—The work was completed in 8 increments, the longest being 900 feet and the shortest 500 feet. The average time required for treatment was two hours per 100 feet of surface, which included the time required to spread the cement, to mix it with the soil, to apply the water, and to compact and finish the surface. This average time did not include the scarifying and pulverizing operations on days when there was no actual processing in progress.

The first two increments completed, which totaled 1000 feet in length, were left uncured after completion. All other increments were cured carefully for 7 days.

The last increment completed, which was about 700 feet in length, was given a surface application of pea gravel of about 25 pounds per square yard applied after compaction was completed. The surface was wetted slightly and compacted with trucks, and the final rolling was

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accomplished with an 8-ton smooth roller. The 25-pound treatment of gravel was apparently excessive, because there was considerable loose gravel on the surface after the rolling was completed, and it is probable that about 15 pounds per square yard would have been sufficient. The appearance of the surface of this increment after completion was similar to that of a stabilized gravel road.

Equipment.—Even though this road was completed as late as September, 1936, the equipment used, when compared with that used on subsequent projects, was deficient in many respects. This is indicated by the average progress of about 100 feet of surface every two hours, or a time of 18 hours for an increment 900 feet in length.

Application of Water.—From 3000 to 5000 gallons of water were needed each day, which was supplied by two distributors having capacities of 700 gallons and 900 gallons, respectively. The water was secured from a stream about one mile away and it required about 45 minutes to fill and empty each distributor. As a result, the application of the water was slow, quite expensive, and introduced a very long mixing period, which tended to reduce the effectiveness of the cement.

It has developed from the construction of later projects that the equipment used for distributing the water requires as much attention as, or more than, any other piece of equipment on the job. It is not unusual during summer months to use as much as 10 000 gallons of water daily, and it has been demonstrated that equipment can be assembled and operated to distribute water at the rate of 100 gallons a minute. This is accomplished by using a 1000-gallon distributor and enough feeder tanks to keep a supply of water on hand sufficient to fill the distributors without delay. That efficiency is needed may be appreciated from the statement that for this rate of application the distributor must be loaded in 5 minutes and emptied in 5 minutes.

Sheeps-Foot Rollers.—The experience gained on this job in compacting the material with sheeps-foot rollers supplied valuable information. Up to this time, experience in the use of sheeps-foot rollers for this purpose had been limited, and no particular recommendation could be made regarding the type which should be used for sandy loams.

The rollers used had the small type of feet, and the construction of the rollers was such that the minimum pressures that could be obtained were about 100 pounds per square inch. These high pressures on small surface areas made the compaction operations slow and tedious. The short length of the project, however, made it impossible to secure another roller without an excessive overhead charge against this short project.

There are many types and designs of sheeps-foot rollers on the market, most of which have one thing in common, that is, that the length of the feet is about 8 inches. The size, shape, and unit pressures on each, however, vary. In general, equipment can be obtained having feet with pressure areas from 5 to 12 square inches, and unit pressures from 50 to almost 250 pounds per square inch. The use of sheeps-foot rollers having pressure areas of about 12 square inches each and loads of about 100 pounds per square inch will compact the sandy loam type of soil more efficiently and more rapidly than the rollers used on this job.

Smooth Rollers.—An 8-ton smooth roller was used for the final finishing operations. This roller gave some trouble because it had a tendency to shove and crack the surface and would often pick up the material from the roadway. It is necessary to work out a definite technique in the use of smooth rollers for this type of work.

Experience on later projects has shown that the moisture content of the surfacing material should be within a range of one-half to one per cent of the optimum moisture content of the soil-cement mixture in order to prevent the roller cracking or pushing the surface. The wheels of the roller should be kept bright, clean, and dry, and the rolling area should not be pitted.

Results Obtained.—The surface of this project when first completed had the characteristic appearance of surfaces of this type. Within two days after the first two increments were completed, hair checks appeared on the surface. These are the two increments which were not cured. It was supposed that the cracks were caused by rapid and excessive drying due to lack of curing and therefore all other increments were cured carefully for 7 days after completion. In spite of this, transverse cracks appeared within three days, and, when the curing material was removed, there was no noticeable difference in the appearance of the cured and the uncured sections.

When this road was examined in December, 1936, approximately three months after it had been completed, transverse cracks and hair checking were evident throughout the project. The transverse cracks occurred at about 15-foot intervals in all increments except that covered with gravel; in this section, cracks did not appear until about two months after completion and then at intervals of about 30 feet.

The only significant longitudinal cracking apparent when the section was examined in December occurred in one increment only, where a continuous crack at approximately the center line extended throughout the entire length of the increment, or approximately 800 feet.

This examination showed that the surface was holding up well in spite of the cracking. It is impossible to predict at this time what the final results will be, and certainly no further statements can be made until the road has passed through the present winter and the coming spring.

Subsequent Studies.—Analyses which have been made since the completion of the road indicated a very serious fault in the preliminary work which probably explains the cracking and other defects which have occurred.

I have already mentioned that the preliminary samples were taken from the old roadway and that all preliminary work was based on these samples. It was found during the progress of the work that the density or weight per cubic foot did not check the predetermined weight made by both the Division of Highways and the Portland Cement Association laboratories. Proctor determinations made on samples of the soil-cement mixture, taken just before the sheeps-foot roller was used, had a weight well in excess of the 112 pounds per cubic foot determined from the preliminary samples. It was impossible during the construction to determine the cause of this variation, from lack of both time and facilities.

The density or weight per cubic foot of the compacted mixture in the finished roadway was determined by the sand method, using Ottawa sand graded between the No. 20 and No. 30 sieves, to reduce the possibility of errors in the determinations.

Tests made by the sand method on each increment a few days after the increment was completed showed an average weight per cubic foot of 120 pounds, or eight pounds in excess of the predetermined weight. Proctor tests made on samples of the mixture taken just prior to starting the compaction operations showed an average of 119 pounds per cubic foot, and the fact that both the Proctor and sand method determinations were so nearly constant discredited any supposition that the variations might be due to the difference between laboratory compaction tests and field compaction made by a sheeps-foot roller.

As gradation is, without doubt, an important factor in the density relation of soils, especially sandy loams, samples of the soil were taken at 100-foot stations throughout the project just before the cement was added. The gradations of these samples were determined later in the laboratory, and the results compared with the gradations, or particle sizes, of the preliminary samples taken from the old roadway.

A comparison of the results disclosed a probable explanation of the variation in densities. The preliminary samples contained 59 per cent sand, 24 per cent silt, and 17 per cent clay. The average results from the analysis of 60 final samples, taken before the addition of cement, showed 74 per cent sand, 15 per cent silt and 11 per cent clay. The final sample, therefore, contained 15 per cent more sand and 15 per cent less clay and silt than the preliminary samples.

This difference in gradation undoubtedly affected the weight per cubic foot of the compacted soil. The results of the Proctor test show that the maximum compacted weight of the preliminary samples was 112.5 pounds per cubic foot, while that of the final samples was 127 pounds per cubic foot. The addition of 10 per cent of cement to these samples lowered the compacted weight per cubic foot, the final sample being more affected than the preliminary sample, probably due to the fact that the percentage of fines present in the final sample was already sufficient, and that bulking occurred with the addition of cement. The weight per cubic foot of the preliminary sample dropped to 112 pounds after the cement was added, and that of the final sample to 125.5 pounds, a difference of 0.5 pound in the preliminary sample, and 1.5 pounds in the final sample.

In order to determine the cause of the variations in densities between the preliminary and final samples a Proctor curve, established from tests of a 10-per-cent soil-cement mixture made from the final soil samples, was drawn and used as a master curve. By plotting on this curve the densities determined on the job by the Proctor method at their respective moisture contents, it was noted that the individual tests checked very closely, and the average of all tests checked within one pound of the master curve. This apparently proved that the difference in the soils caused the variations in densities. If this conclusion is correct, the project was completed with an error in the moisture content due to having set up construction requirements on samples not representative of the finished project.

The optimum moisture content shown on the master curve was 10 per cent and, as a 16 per cent optimum moisture content was set for the job, and as the average moisture content for the entire job was about 14 per cent, the project was constructed with an error of from 4 to 6 per cent in the moisture content. Further studies are now being made in the laboratory to determine the effect of using an optimum moisture content so much in excess of what it should be and these results will be compared with what happens on the road as shown by later examinations.

Conclusions.—It is certain that should another section of this type be constructed in Illinois, care will be taken to avoid the conditions described in this paper.

The results from this job show the importance of care in taking the samples from which the job data are obtained. These samples should be well located and of sufficient number, and they should not, under any circumstances, be taken until the final grading has been completed so that it will be certain that they represent the soil actually to be processed.

The equipment for mixing the cement with the soil, and distributing and mixing the water, and the equipment for the final compaction operations must be such that the actual time of processing will be reduced to a minimum.

The fact that the results from this job may not be comparable with those obtained on similar jobs constructed at a later date may be attributed to the manner in which the original samples were taken, which caused erroneous preliminary data and resulted in the use of a much higher optimum moisture content than required, and the fact that the type of equipment used resulted in an excessively long mixing period which undoubtedly reduced the effectiveness of the cement.

VIII. CONSTRUCTION OF EXPERIMENTAL STABILIZED SOIL-CEMENT HIGHWAY

R. O. Ericson*

Construction of the first stabilized soil-cement highway in Illinois was undertaken in Winnebago County, September 1936, as an experiment, under the joint auspices of the County Highway Department, the Illinois State Highway Department and the Portland Cement Association. The scene of this experiment was in the Eastern part of the county where the type of soil was best suited for this type of construction.

The road selected for this experiment was a stretch 6000 feet in length having a rolling grade. This road serves very little traffic except pleasure cars during evenings and holidays in summer months. Grading and culvert work were completed about a month and a half before the stabilization work was started. Approximately forty-five per cent of the road was in cuts, and the remainder of the improvement was embankments having a maximum depth of three feet.

The work was performed by the county crews using county equipment. The following equipment was used on the work:

(1) Power operated grader with 12-foot blade and 20-inch mold board

(2) Scarifier fitted with shoes or sleds to control depth of scarifying

(3) Two offset disc harrows, one 20-inches and one 24-inches, fitted with baffle plate on outside edge to prevent other disc from throwing excessive material on to the shoulder

(4) Two water distributors, of one thousand gallon capacity, with 20-foot spray bars

(5) Two sheeps-foot rollers, one single and one double unit, fitted with leveling bar to smooth out roller marks

(6) One 8-ton smooth wheeled roller

(7) One 60-H.P. tractor for drawing scarifier and blade grader

(8) Two 35-H.P. tractors used for discing and compacting

(9) One 2-ton truck used for moving material for "turn-around"

(10) Water supply and gas tanks

In addition to this machinery there was available other equipment which was not used to any measurable extent, as it did not expedite the progress nor have advantages over the equipment just listed.

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The construction crew was composed as follows:

Superintendent, 3 tractor operators, 1 blade grader operator, 3 truck drivers, 8 laborers to distribute cement, move "turn-around" and other work, 1 roller man; 5 trucks and drivers were used for about three hours each day to load and distribute cement.

Prior to commencing the actual processing operations a certain amount of preliminary work was necessary. First, the roadway was bladed to smooth out any irregularities in profile and crown. Upon completion of this work stakes were set at fifty-foot intervals, twelve feet on each side of the centerline to provide means of horizontal and vertical control. Level readings were then taken on ground at the centerline (ground line) at each fifty-foot interval, and the stakes were driven to an elevation of three-tenths of a foot above the ground elevation at the centerline.

The roadway was re-graded, correcting the crown where necessary. In order to control depth of treatment, measurements to the roadway surface were taken below a string stretched between the stakes, and readings were taken at the centerline, quarter points, and edges.

This concluded the preliminary work and the roadway was ready to be scarified. The soil was loosened for a depth of six and one-half inches to provide sufficient material for the six-inch compacted surfacing. Following the necessary scarifying operations the loosened material was bladed to the center and the edges cut to correct line. The soil was then pulverized by using two weighted disc harrows. After the soil had been partially pulverized the subgrade was cut to proper subgrade. This was accomplished with the blade grader by windrowing the pulverized soil along the edges and then cutting the center portion of the roadway to the required depth. After completing this operation the outer portion of the roadway was cut to subgrade by windrowing all material to the center.

The pulverized and loosened soil was then leveled and the work of pulverizing continued until the material was free from lumps. The soil was not entirely pulverized, as a certain amount of pulverizing was accomplished during the mixing of cement and soil.

The pulverized soil was leveled approximately to the desired cross-section and the outer twelve inches of soil was bladed to the center. Then the cement was placed directly on the roadway, unloading directly from the trucks, and spread with hand rakes. The cement was distributed in three longitudinal rows, three sacks in each three and one-third feet of roadway.

The disc harrows were used to mix the soil and cement in the same manner as in pulverizing the soil. The discs were not of sufficient diameter to effectively mix the cement with the entire depth of pulverized soil. This difficulty was eliminated by first mixing the cement with the upper four inches of soil, and then windrowing the mixed materials on to the shoulders. The unmixed soil was bladed over the two windrows of mixed soil and cement, and then returned to the roadway so that the mixed soil and cement was placed on the subgrade and the unmixed soil on the surface. The disc harrows continued the mixing until the mixture had a homogeneous and uniform appearance.

Immediately after the soil and cement were mixed the moisture content of the mixture was determined, and the quantity of water necessary to obtain the optimum moisture content was computed. The water at first was applied uniformly over the entire width of the roadway at the rate of eighteen hundred gallons to each application. Each application or increment of water was incorporated by disc harrows in order to avoid concentration of water near the surface. After each application of water the material was mixed with disc harrows until the water was uniformly mixed and distributed throughout. The application of water and mixing were repeated until the required optimum moisture content was reached. The discs were ineffective in mixing the entire depth of material. This difficulty was overcome by placing on the shoulders about one-quarter of the soil and cement mixture before applying water. The water was applied to the lower layer and mixed into the soil-cement. The application of water and mixing were continued until the optimum moisture content was obtained. The mixture previously placed on the shoulders was returned to the roadway and shaped to proper grade. The application of water and mixing continued in the same manner as for the lower layer.

By observing the results produced by the 24-inch disc as compared with those obtained by the 20-inch disc the conclusion was reached that a 30-inch disc would be effective in mixing the entire depth at one time.

The next step in the construction of the roadway was compaction and final rolling. Compaction of the mixture was accomplished with two sheeps-foot rollers starting on the edges, and working to the center. After the sheeps-foot rollers had compacted the material the mulch remaining on the surface was bladed onto the shoulders, and the roadway shaped to the desired crown. The surface was then rolled with the 8-ton roller until thoroughly compacted.

The resulting surface obtained by the 8-ton roller was not satisfactory. The roller marks were unsightly and ruts were formed due to the material adhering to the roller wheels. The roller produced a wavy surface in places, and some longitudinal checking. The longitudinal checking seemed to increase as the rolling continued. These objections occurring during the final rolling were overcome by applying uniformly about fifteen pounds of pea gravel to the square yard over the surface prior to final compaction. The amount of pea gravel could be reduced to at least ten pounds to each square yard.

The pavement was protected against rapid drying for a period of from five to seven days by applying a covering of earth approximately one and one-half inches in depth. This covering was kept moist by the application of water. The material used for covering was borrowed from the shoulders. Considerable longitudinal and transverse checking occurred after the protective covering was removed. The surface which was covered with pea gravel seems to be free from checking, at least, checking is not visible. We have no explanation for the apparent absence of checking on this portion of the work.

At the end of each day's work a "turn-around" was constructed by placing six inches of earth on the roadway to prevent the machinery damaging the surface. This method of building the turn-around was the cause of considerable difficulty in obtaining a satisfactory connection with the previous day's work. In approaching and leaving the turn-around the discs had a tendency to carry material from the turn-around and roadway and deposit it at the beginning of the new work. This resulted in defective work at the junction with the previous day's work, due to inadequate mixing of the lower material. This trouble was overcome by using steel plates for the turn-around near the junction in place of earth.

The construction cost of this section, including machinery rental, moving costs, gasoline and oil, delivery of material, and freight on rented equipment, amounted to twenty-eight (28) cents per square yard.

This figure includes cost of making V-frames for discs, level attachment for sheeps-foot rollers, and other costs which could be eliminated if another section of road should be built. The cost of this type of work should be reduced five (5) to ten (10) cents per square yard.

The cement used for this section was 0.1125 of a barrel per square yard, the cost amounting to twenty-three (23) cents per square yard. The total cost was fifty-one (51) cents per square yard.

At this time I hesitate to make any comments as to the service which may be expected from this type of construction. However, I do think that this type of road has possibilities and merits a fair trial. If some of the experimental work does not prove up to expectations, I still believe that it does not mean that it will not be successful, because many improvements can be made in the construction methods which I am sure would improve the strength and quality of this type of road.

At the present time the section built in Winnebago County has not shown any detrimental defects due to the present winter. What will happen during the spring thaw remains to be seen.

I am confident that with improved methods of mixing and compacting a much better pavement will result.

IX. POSSIBILITIES OF THE STABILIZATION OF EARTH ROADS WITH SOY BEAN OIL

JOHN S. CRANDELL*

In 1936 a thesis on the subject of the stabilization of earth roads was written by Fu Hua Chen, a Chinese graduate student, at the University of Illinois. In this thesis the various bitumens and portland cement are appraised, and then soy bean oil is investigated as a possible substitute for the other materials. To my knowledge this is the first time that such an investigation has been made. Mr. Chen felt that if it were successful soy bean oil would be of great value in China where bitumens are costly and vegetable oils are cheap. He therefore took special pains to try to arrive at some definite conclusions as to its suitability.

In Illinois we are beginning a soy bean campaign, and it will not be many years before we may have a surplus of beans and, consequently, of oil. It will be of interest to our farmers to know the results of the investigation at the University of Illinois.

Soy beans contain about 18 per cent of oil. The yield from a ton of beans will run about 250 pounds of oil and 1600 pounds of meal. The oil produced is a semi-drying type. The smooth flowing quality and the elastic film produced in drying make soy bean oil desirable for the paint trade. These properties are also of value when the oil is mixed with soil.

Several Illinois soils were treated with oil, asphalt, and tar. It was found in the laboratory that soy bean oil is apparently as good a stabilizer as the other materials. The treated soils were all subjected to the same tests, and in some of these the samples treated with soy bean oil proved to be superior to the others.

The thesis is available at the University of Illinois library, and therefore the tests run, their significance, and their outcome will not be reported here. It is sufficient to say that the results, judging from a laboratory standard, indicated clearly that soy bean oil will bind the soil particles together, will waterproof the surface of a soil road, and will resist freezing and thawing tests as well as asphalts and tars.

It should be noted that insects love soy bean oil, and that it therefore must be poisoned before use. A three per cent addition of coal tar creosote prevented ants and other such creatures from eating the oil.

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Plans were made for a road demonstration, but the price of the soy bean oil soared so high that this was not undertaken. Crude oil apparently is as suitable for use as refined. The farmers of this state should be advised that when they have a surplus of oil that cannot otherwise be disposed of, there is an excellent outlet in the stabilization of their earth roads. This brings the farm-to-market road one step nearer in many cases.

X. SAFETY ON ILLINOIS HIGHWAYS

H. H. Harrison*

As a usual thing, when the assignment of a subject for a paper has been made, the writer is limited to a single line of thought in developing the subject matter. The topic given to me is so broad in nature that instead of being limited, I find it a little difficult to pursue a single line of thought without branching off into other related subjects. I have chosen to give you in this paper somewhat of a picture of what constitutes the traffic accident problem of today, with particular reference to Illinois.

While I am reluctant to quote statistics, I believe the risk of boring you is justified in order that you be better informed of the situation which has faced the motoring public in recent years and which is showing but little evidence of improvement. No doubt the figures to follow will be of some interest and I ask, therefore, that you bear with me.

During 1936, Illinois accounted for 2461 deaths of the national total of approximately 38 500. This figure represents an increase of 5.5 per cent over 1935, and is only 4 per cent below our all time high of 2575 registered in 1934. We have raised our position, or perhaps it is more correctly stated to say we have lowered our rating, in the national record of gross totals from fourth place in 1935 to second place in 1936. Illinois is now second only to California, where traffic accidents accounted for the death of 3086 persons last year.

There is not much consolation even here in the fact that one other state had a worse record than Illinois in total traffic deaths. From statistics compiled by the National Safety Council, we find in comparing records of various states on a gasoline consumption basis, which is equivalent to the vehicle miles travelled, that we have a higher death rate per ten million gallons of gasoline consumed than either California, New York, or Pennsylvania, which with Illinois have held the high record for all time. Of this group of four states having by far the largest annual number of traffic deaths, Illinois has the worst gasoline consumption record, with a rate of 20.7—California is second with a rate of 19.2—Pennsylvania third with 18.9—and New York fourth with 15.0.

I have purposely given you the darker side of the picture first. Now, let us compare the trend in Illinois with the nation-wide record. In 1934, when we reached our all time high in total fatalities, our death

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rate amounted to 26.3 per ten million gallons of gasoline as compared with the national rate of 23.2; the Illinois rate was reduced to 23.3 in 1935, while the national rate dropped only fractionally to 22.8; even though we registered a 5.4 per cent increase in total deaths in 1936 over the previous year, the trend of our rate was still downward with a score of 20.7 against the national record of 21.4. It is noteworthy that, in the course of a three year period, we have realized a reduction of 21 per cent in the rate, which means of course that there was a proportionate gain in miles travelled per fatal accident. A further examination of the individual record of all states on a gasoline consumption or mileage basis discloses that we rank 17th, or, in other words, 16 states have a worse record than Illinois.

The question in next logical sequence is what are the principal causes of, and what line of endeavor is most needed to bring about a reduction of traffic accidents. An analysis of national, state, or local statistics proves conclusively that of the three elements which enter into every accident, namely, the Driver or Pedestrian, the Vehicle, and the Highway, more than 85 per cent of all traffic accidents may be charged directly to the driver or pedestrian. Some authorities go so far as to blame all traffic accidents on the human element for the reason that no accident could have occurred unless the minds of those involved had failed to properly take into account the conditions which induced the accident.

This presumption does not mean that highways are now as safe as can be constructed, or that motor cars have reached the ultimate in safety of control or structure. It seems to me that the opposite conclusion is more nearly true, in that a greater burden is placed upon engineers to design highways which will tend to prevent accidents in spite of human errors, and that automobiles must be built with an even greater factor of safety to compensate for the weaknesses of the human element.

Ordinarily we may presume that the inherent safety of a highway is dependent on

(1) Type, width, and alignment
(2) Gradients
(3) Traffic control devices
(4) Surface condition
(5) Sight distance
(6) Traffic density

It is economically impossible to accomplish a 100 per cent correction of all physical faults admitted to be present in our street and highway system. Highway authorities generally recognize the need for modernization, but the lack of funds with which to do it is the governing factor that cannot be side-tracked. It will require many years to revamp our highway system to the extent that it can be classed as accident-proof.

Much attention is now being directed to the need for fixed lighting of rural highways in certain high-accident areas to eliminate a large percentage of darkness accidents. The expense of installing and operating a system of highway lighting, however, is so great as to warrant a careful study of accident causes before selecting certain sections for this treatment.

We must consider, therefore, that insofar as immediate relief from the present situation is concerned, our highways are now reasonably safe, subject of course to weather conditions, and the adequacy of protection furnished by signs, signals, and markings.

The same is also true of the motor vehicle which we may think of as being the connecting link between the roadway and the load to be moved. Our common conception is that a vehicle is safe if the brakes, lights, steering gear, and tires are in good condition, and it is structurally sound. Such strides have been made by automobile manufacturers in perfecting these inherent safety features that even the lowest priced models of today seem a miraculous development when compared with the cars produced only a few years ago.

Design of motor cars is not fixed, however, as is the design, location, and type of highways. Each new model brings forth some new feature. There are still a few improvements which might be added as standard equipment or as a further service to customers which, in my opinion, would be conducive to greater safety. Some of these are:

(1) Improved headlights, perhaps to the extent of polarization

(2) Addition of signalling devices controlled from inside the vehicle

(3) Elimination of body colors and combinations of colors which tend to make the vehicle less visible to other drivers under different light conditions

(4) The making available to each customer through the retail dealer of a complete course of instruction in safe operation when the vehicle is delivered

(5) More careful factory inspection of the vehicle after assembly. Tests made in inspection stations throughout Illinois disclose the fact that many new cars are delivered with wheel balance and alignment out of adjustment, and with headlamps out of focus.

How safely a driver may operate his car is dependent on his physical and mental condition, his experience and training, and last but not least on his temperament. When we think of the varying degrees of training, experience, physical qualifications, and temperament of our millions of drivers, together with the driving problems which are daily presented for their immediate and correct solution, it does not seem strange that accidents occur. Rather, it seems unbelievable that there are not still more accidents.

It remains, therefore, that the present day problem is chiefly one of effecting more adequate training and control of drivers and pedestrians. This can be accomplished in two ways—through Education, and Enforcement, which itself is a form of education.

Believing that the Division of Highways, which has designed, constructed, and is maintaining our primary highway system, had some further obligation in the safety of owners and drivers of vehicles operating over the system, Department officials two years ago directed that a state-wide educational program be undertaken to inform the public regarding the accident situation, and of the ways traffic accidents can be avoided. Most of you here today have played an important part in that program. While I do not consider it necessary to recount in detail what we have been doing, I shall later summarize these activities.

First, however, I should like to discuss a little more in detail one of our most important activities which I believe to be vital to the safety educational program. I refer to the collection of data relating to traffic accidents. This has been made possible through the enactment of legislation requiring that all drivers involved in each accident which results in the injury to or death of any person must file a report of the accident with the Department. This law became operative on August 1, 1935, and we now have the experience of eighteen months of such reporting. The data thus collected will become more useful as time goes on and we are enabled to make direct comparisons by routes, counties, cities, months, seasons, etc.

At the present time our statistical staff consists of an engineer-statistician and a draftsman, together with five stenographers and clerks. The small size of this staff has permitted only the compilation and publication of statistics of a more general nature. We realize full well the need for more detailed and localized studies, and it is our hope that in the near future we will be able to carry on such studies and to furnish you with information in a more useful form.

Probably most of those present have not had opportunity to examine our summary tabulations which list types and causes of traffic accidents, so I shall take a few minutes to give you only the major points of interest.

During the calendar year of 1936, 15 765 accidents were reported to the Department. As nearly as we can estimate, this figure represents approximately 85 per cent of the reportable accidents occurring down-state, and 35 per cent of those in the City of Chicago. In this total number of accidents there were 2461 persons killed, 23 389 persons injured so badly as to require the services of a physician, and 20 332 drivers were involved. I wish to point out here that even though we do not receive reports of all accidents, we do obtain records of 100 per cent of the traffic fatalities, so that figure may be accepted as correct except for minor year-end adjustments.

Traffic accidents occurring with the greatest frequency are those involving pedestrians. Nearly one-third of all the 1936 accidents were of this type. No doubt this percentage would be appreciably increased if all Chicago accidents were reported. Slightly more than 43 per cent of all traffic fatalities were pedestrians. In our analysis of all reported accidents, 27 per cent were shown to have been caused by pedestrians. National figures for 1926 show that 16 650 pedestrians were killed in traffic accidents—an increase of 33 per cent during the 10-year period since 1927.

Next in importance are those accidents resulting from the collision of two or more automobiles, and collisions with fixed objects. These two types of accidents represent 61 per cent of the total number, and have accounted for 41 per cent of the fatalities.

In 1936, automobile-train collisions accounted for 249 persons killed and 441 injured in 385 reported accidents. From January, 1930, through December, 1936, a seven year period, 1323 persons have been killed in Illinois in grade crossing accidents. Comparing the monthly average fatalities over this period, June has the lowest record. The curve of monthly averages rises uniformly, approaching the maximum point in December, and, remaining above the medium through March, returns to the minimum in June.

An alarming increase has been registered in accidents and deaths of bicycle riders. A total of 507 such accidents, resulting in 45 deaths, was reported during 1936. This diversion has increased so in popularity in recent months as to constitute a major traffic problem. In an effort to induce young people to ride safely and to accomplish some uniformity in riding practices, the Department published and distributed during the year approximately 250 000 cards listing 12 rules for safe bicycling.

The same principal causes of accidents have predominated during 1936. Those chargeable to the motor vehicle driver are as follows:

(1) "Vehicle operated too fast for conditions" caused 1627 accidents, or 10.2 per cent, and resulted in 200 deaths.

(2) Drinking drivers are charged with causing 1352 accidents, or 8.5 per cent, which resulted in 175 deaths, and 1177 injured.

(3) Inattention accounted for 1146 accidents, or 7.3 per cent, causing 217 deaths and 929 injured.

(4) Operating on the wrong side of the road was responsible for 1076 accidents, or 6.8 per cent, causing 97 deaths and 979 injured.

(5) Right-of-way accidents at intersections amounted to 1075, or 6.8 per cent, and were the cause of 54 deaths and 1021 injured.

(6) Failure to stop at a stop sign, perhaps the most inexcusable offense of all, caused 1003 accidents, or 6.3 per cent, and resulted in 88 deaths and 915 injured.

Accidents due to these major causes, combined with those accidents caused by pedestrians, constitute approximately 73 per cent of all traffic accidents.

Our efforts to inform the motoring public of the seriousness of the traffic situation have consisted principally in the publication of safety material, and in presenting safety talks in schools and before luncheon clubs and other civic groups. During the past two years almost one thousand safety talks have been presented to a total audience of approximately 175 000 persons. This does not include 173 radio talks which have been given by engineers and officers of the state police.

Showing of safety films in theaters and schools, and before all interested groups throughout the state has been carried on as a part of this phase of the program.

A total of 1 330 000 safety bulletins has been distributed. The demand for these statistical pamphlets has grown to such an extent that we are now publishing 170 000 monthly.

Several safety cards dealing with different phases of traffic safety have been published and distribution made through outlets which would gain the greatest effect. These have consisted of 770 000 Safe Driving Rules cards, 700 000 Children's Safety cards, and, as previously mentioned, 250 000 Safety Rules cards for bicyclists. In addition, approximately 200 000 windshield stickers, car record tags, and instrument board safety tags have been issued.

One of the major activities carried on jointly by our engineers and police officers is the promotion and training of school safety patrols. To date 90 schools have been given this service, and in most instances the belts and badges have been furnished by the Department.

You are all familiar with the program of first-aid training. Since this policy became effective, almost 3000 engineers, maintenance men, and police officers have been given the standard 15-hour course. During this course, instructor's training has been given to 35 police officers and engineers, so that we are now able to carry on the training of new men, and to review classes using instructors from the Department staff.

A few months ago the State Police purchased two safety cars which were provided with first aid supplies and equipment and also a public address system. For the time being these cars and police officers are assigned to the Traffic and Safety Section to assist in public educational work. One car is assigned to the northern three highway districts, and the other operates in the seven down-state districts. Assistance is given to local police in all cities visited, as well as safety talks in schools and interested local groups. The public response to this activity has been most favorable. It is likely that two or possibly three more cars and officers will be assigned to this work during the coming year.

Another important phase of the safety program is the recognition of public garages as official inspection stations. To date some 50 stations in 40 different cities throughout Illinois have been designated as official. There has been considerable delay in inaugurating this program because of the research work necessary before it was possible to publish a manual of rules and regulations. Inspection of stations with subsequent recognition will proceed at a more rapid rate in the future. We anticipate the recognition of between 150 and 200 stations before October 1. Police officers making roadside inspection of motor vehicles will now be able to send cars found with certain defects to official stations for a complete inspection.

Perhaps our most important activity is in connection with our entry in the National Traffic Safety Contest. A great amount of work has been done by our district men in promoting the contest and in assisting cities to carry out the program necessary to gain recognition. Through our efforts Illinois was able to win first place in our group of states in 1935. Final reports are now being prepared by all of the 117 eligible cities in the state for the close of the 1936 contest. We are hopeful of again winning this honor by our efforts during the past year.

Experience gained in the sponsorship of the Traffic Safety Contest has proven that to merely obtain the entry of each city is only a minor part of the problem. It has been our endeavor to persuade and assist all cities to undertake a safety program suitable to their requirements. This has consisted in the formation of safety councils made up of members from representative civic groups; the installation of accident reporting systems, including field investigations, preparation of collision diagrams, and maintenance of spot maps, as well as the development of a filing system; the assistance to city officials in conducting traffic density, parking, and observance surveys; the coöperation with city officials in conducting street surveys to determine the need for physical changes and traffic control devices.

The contest affords us our best means of contact with these cities which include a population of 1 856 253 exclusive of Chicago. Whether or not we are able to win the highest award in the contest, the fact remains that here we have opportunity to exert our influence to the end that tangible results will be obtained.

Two years ago, we prepared and were successful in having passed the Uniform Act Regulating Traffic on Highways. This act was patterned after the national uniform code, and Illinois may now be recognized as having modern traffic legislation. The Department has recently prepared bills which already have been introduced in the legislature for a standard Driver's License and Safety Responsibility Law. The bills have been written to give the Department the administration of both acts. We have been encouraged to believe that they will be passed at the present session.

I have described for you our principal activities in traffic accident prevention work which affects the general public. Before closing, I would like to call your attention to the rather serious situation which we are facing in the matter of employee injuries and accidents involving state equipment.

During the past year four Department employees have been killed and 461 others injured while engaged in maintenance work. The hazard under which the men in our repair gangs are working is evidenced by the fact that all four fatalities resulted while the men were working on the pavement under the protection of signs and portable barricades.

In addition to the death and injury accidents, there occurred 278 property damage accidents involving state equipment. Approximately 40 per cent of these occurred during snow removal or cindering operations. Most of these, of course, were beyond the control of our employees, but resulted from conditions which we may be able to overcome. For example, redesign of our snow plows to prevent the tripping effect which causes some loss of control may be possible and is now being considered.

In an attempt to reduce the number of employee accidents, a code of safety rules and regulations has been adopted and is now in general effect. By conscientiously following these rules, a material reduction in accidents will undoubtedly result. To better enforce the application of these rules, safety councils or accident review boards have been organized in each district. These councils will review each accident and point out to all employees how such an accident can be avoided in the future. While this plan has been in operation only a short time, we are much gratified by the reports and minutes of the council meetings which have been received from many of the districts.

The account of our activities which I have just given you covers the major points of the program to be carried on during this year. We ask from you only the same degree of coöperation which you have given since the beginning of our program.

XI. TRAFFIC SIGNALS—WHAT THEY ARE AND WHAT THEY DO

C. C. Wiley*

The ubiquitous red and green lights of the traffic signal are said to be contributing to the growing use of blue lights on Christmas trees since something is needed to distinguish the trees from main street or the court house square.

In some way " the dear people" have acquired a firm but erroneous belief that signals are the one and only sure and infallible cure for all traffic ills. Something must be done to eradicate this blind worship of signals else we are likely to be faced with an epidemic of pernicious signalitis more dire in its possibilities than some of our dreaded diseases. It is high time for the powers that be to "crack down" hard on the indiscriminate, excessive, and persistent demands for signals, and insist that signals be used only when and where they are needed and can perform a real service to traffic.

The Illinois Manual of Traffic Control Devices says some excellent things about signals that would probably open the eyes of many people. Let me urge the careful reading of the section of the manual relating to signals, by which I mean read what is said, and not what the reader chances to *think* is said.

The modern traffic signal is an electro-mechanical device for indicating to vehicle drivers when a section of the highway is presumably free for their use. Its objects are to facilitate traffic movements and promote traffic safety. Being a creation of man it can display only that degree of human intelligence which can be built into it. When this does not suffice added intelligence is supplied by a traffic officer who supplements or temporarily supercedes the signal. But there are officers and officers, as witness the remark by a local business man in discussing traffic conditions. He said, "That cop could get up a traffic jam with only one car."

Signals are of two types, the time-cycle type and the traffic-actuated type. In the first the indication follows a cycle as unchanging as the Laws of the Medes and Persians. In the second the cycle is flexible under actuation by the vehicles themselves. Let us first consider the time-cycle signal, and for simplicity assume a right angled intersection.

Some of the advantages claimed for such a signal are (1) orderly

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traffic movements, (2) elimination of discretion action by the drivers, (3) reduction of certain types of accidents, (4) prevention of speeding, (5) interruption of dense or fast traffic at minor crossings, (6) continuous traffic movement at a definite speed by coördinating a series of signals, (7) greater economy than manual control.

Some of these can be readily accepted, while others are subject to reservations. The signal can eliminate only the discretion as to when to enter the intersection. It cannot furnish the discretion necessary to pass through the intersection properly. If it could it would be able to reduce *all* kinds of accidents instead of only some types. The control of speeding is desirable, but just what the signal can do is not certain until an adequate definition of speeding free from bias and unsupported opinion is available. Evidence points to a signal being able to control speeds only when it is part of a coördinated series of signals. Isolated signals often increase speeds because drivers try to get through on the green light. The economics of signal control is still in an elementary stage. So far only the costs of installation and operation have been compared with the salary of the officer. When costs to traffic and the factors of convenience and safety are included the picture may change.

A time-cycle signal may exhibit some or all of the following disadvantages (1) increased number of stops, (2) undue delay, (3) added costs of vehicle operation, (4) increase in certain types of accidents, (5) diversion of traffic to other routes to avoid the signal, (6) inciting to disregard of regulations, (7) increased approach speeds.

The first three, stops, delays, and costs will be discussed in a concrete example later. Due to the multiplicity of traffic movements which the signal cannot control, certain conditions are likely to be aggravated and result in an increase of accidents of certain kinds. The diversion of traffic so as to miss the signal is thought by some to be an advantage, but this overlooks the probability of increased hazards on the alternate routes. If a signal is unwarranted there will be a natural tendency to disregard it. This disregard does not discriminate between the good and bad, hence will spread to all regulations.

Let me illustrate. Three new signals were recently installed in Champaign. Immediately there was a marked increase in over-running the amber at all the signals in the city, followed by indications that stop signs were also being disregarded, although the city has been conservative in their use. Apparently some of this has been observed, for several people have asked, "Aren't we getting too many signals?"

In considering a proposed signal the physical layout and conditions on the approaches should be carefully investigated. Traffic troubles are frequently the result of bad layout of the intersection or of improper use of the approaches. Consequently they may be most effectively and economically corrected by changes in the layout and the proper use of the approaches instead of by a signal which perhaps cannot do the job at all.

Traffic volumes of course play an important part in determining the need for a signal. The Illinois manual provides that the total traffic from all directions must average at least 1000 vehicles per hour with at least 25 per cent entering on the minor street for at least six hours between 7 a.m. and 7 p.m. Unfortunately it does not state on how many days or at what season. Consequently many people think it is only necessary for it to occur once at any time. There is a further idea that if these limits do exist a signal is automatically warranted. This is not the case.

The manual says, "The *minimum* vehicular volumes which warrant the installation and operation of traffic control signals—must average *at least*" the limits cited. Note the words "minimum" and "at least." This clearly means that a time-cycle signal should not be considered at all until these volume conditions are met, and it is quite likely that the volumes should be much higher before traffic warrants the signal. This is emphasized by the fact that these limits are appreciably lower than those recommended by the A.A.S.H.O. and the National Conference on Street and Highway Safety.

The manual also says that when the traffic falls below one-half of these limits for two consecutive hours it shall be operated as flashing caution or stop signals. If this were enforced we would not find signals running in the wee small hours, or else turned off completely, leaving no protection of any kind.

Cross traffic alone is easy to control but as turns increase troubles multiply, especially where the pavements are not wide enough to separate turns from through movements on the approaches. A separate interval in the cycle may be provided to clear the way for left turns, but the Illinois manual says that such turns must reach *at least* 300 in the maximum hour and cross a stream of regular volume *before* such an interval is open to consideration.

In the past, traffic counts for signal studies have been made on an hour-by-hour basis. Such periods are entirely too long and may be misleading. The counting intervals should not exceed 15 minutes while minute-by-minute counts will often be so valuable as to justify their somewhat higher cost.

Stops and delays are highly important as they measure the effectiveness of the signal in facilitating movements. They can be readily determined for the existing conditions and are not hard to estimate for a given type of proposed signal. They should be considered in conjunction with the traffic volumes and movements.

There is a general belief that pedestrians should move with the signals, but there seems to be little reliable data to support such a belief. On the contrary, many cities have found it practically impossible to compel pedestrians to obey the signals. Where there are many turning movements with only moderate cross traffic it may actually be safer and more convenient to move against the signal. On very busy streets the pedestrians often appear to conform automatically to the signals, but in reality they are moving with respect to the vehicular movements, and pay little direct attention to the signals.

The minimum pedestrian requirements which may warrant a signal as stated in the Illinois Manual are certainly low enough, but even at that they are an excellent deterrent to the demands for signals at locations where there are perhaps rather heavy pedestrian movements at widely separated intervals, such as school crossings. There seems to be a universal obsession to do something for somebody whether it needs to be done or not, and this leads to lots of "traffic tinkering."

Often school authorities or organizations demand signals or other special regulations "to save the lives of the children." This is the kind of pernicious pressure that results in unnecessary regulation that frequently makes conditions worse. The school boy patrol has proved so universally effective that accidents at school cross walks have been practically eliminated. Why then should costly devices be installed that could do no better and would be a nuisance to vehicular traffic?

The manual gives a minimum accident warrant for signals, hence accident records, if available, should be carefully studied. But even a rather bad accident record does not of itself warrant a signal. The accidents should be carefully analyzed and classified into types which a signal can reduce, which the signal may increase, or which may be unaffected by a signal. Only those which are capable of being reduced should be considered in warranting the signal and these should be weighed against the possible increase of other types. All too often an accident such as one resulting from the failure of a car to obey a stop sign is made an excuse for a signal. Better enforcement of the stop signs is needed rather than a signal in such cases.

To bridge the gap between the ordinary 2-way stop and a signal the 4-way stop has been introduced. In rare cases it may be justified but often it is merely begging the question. A careful study of accident records and other conditions may often show that the real trouble lies in stopping the traffic on the wrong road and that all that is needed is to shift the stop signs to the other highway.

In order to determine whether conditions warrant a signal it is obvious that a thorough investigation is necessary. Studies should be made of physical conditions including items outside the right of way as well as in it. Approach speeds, parking conditions, traffic volumes, and turning movements, as well as accident records need careful analysis based on accurate and complete data.

The Illinois manual should be commended for setting up a minimum requirement of post signals on the corners so as to give far-left and near-right indications in all directions. On wide streets, where jogs exist, or if pedestrians are many, a far-right may be added to good advantage. A near-left is rarely needed.

Since the signal merely controls the entries into the intersection the division of time between the two streets should be based on maximum opposing entries and not on the total traffic on the two streets. Thus if the entries from the N.S.E.W. in a 15-minute interval are 20, 60, 100, and 90, respectively, the cycle ratio should be on the opposing entries of 100 from the east and 60 from the south giving a cycle ratio of 1.7 instead of 2.4 as would result from using the total traffic on the respective streets.

The length of the minimum green indication should be such that the normal maximum number of vehicles which accumulates during the red indication is allowed time to clear the intersection. On the average street this is about 15 seconds. Traffic becomes restless if held more than about 40 seconds on the average street, and therefore the division of time should be kept near these limits if possible. In the example cited, with a 15-second indication on the minor street the interval on the major street would be 1.7 x 15, or a 25-second interval, giving a total cycle of 40 seconds. Studies in Washington, D.C., (Pub. Rds. Vol. 14, No. 12, Feb. 1934) indicate that short cycles are better than long, hence such a 15-25 cycle would be better than a 20-34 which has the same cycle ratio.

As a concrete example we will consider the intersection of Green and Wright streets in Champaign at the edge of the University campus, where records both before and after the signal installation are available.

The intersection is right-angled, but Green St. has a jog of about 15. ft. The pavement widths are 52 ft. north and south, 33 ft. to the east and 44 ft. to the west, with corner radii of 12 to 20 ft.

Traffic counts in April show a little over 800 vehicles per hour while in early October the counts run about 1100 per hour. The average daily traffic is estimated as 12 000. Entries from Wright St. amount to 29 per cent, with 71 per cent from Green St. Through traffic on Green St. is about 55 per cent of the total, but only 6 per cent on Wright St. The heaviest turning movement is 17 per cent on the S.E. corner with 10, 5, and 7 per cent, respectively, at the S.W., N.W., and N.E. corners. The largest peak occurs for 15 minutes just before noon, when all traffic flows are practically doubled; the heaviest sustained flow is from 4 to 6 p.m.

The pedestrian traffic from 8 a.m. to 6 p.m. averages about 700 per hour crossing Green St. and 550 crossing Wright St. About one-half of these cross during the first 40 minutes of the hour, and the other half during the last 20 minutes. The maximum hourly pedestrian flow recorded for the entire intersection was 3900.

Note that the vehicular volume is very close to the minimum warrant set up by the Illinois manual, while the pedestrian volume greatly exceeds the minimum of 350 per hour across a vehicular flow of 750 per hour set by the manual. Anyone who assumes that conditions meeting the minimum requirements of the manual justify a signal would certainly install one here. But let us see what happened when a signal was installed.

The intersection was originally guarded by standard stop signs on Wright St., and there were few violations. The signs were replaced by the signal in the fall of 1935. The original cycle was very bad. A study of the available data showed the traffic ratio to vary from 1.47 to 4.20 with an average of 2.47. A ratio of 2.5 was chosen as best fitting prevailing conditions. On this basis a cycle of 56 seconds was set up, divided 16-40. Later this was changed to 18-40 because of the jog, and a signal at Green and Mathews on the other side of the campus, but this seems to have made no appreciable change in traffic behavior.

Accident records tell us very little. There had been no major accidents for some time preceding the installation, except that a pedestrian was rather severely injured by being struck from the rear by a car making a left turn. This is a type of accident that a signal cannot control. Since the signal was put in there have been no injuries but there have been a number of minor collisions, the worst involving three cars, two of them making left turns, which is again a type of accident that the signal cannot control, and generally increases.

Approach speeds appear to have increased but so far no attempt has been made to measure them.

Pedestrians cross with little regard to the signals. The approaches are so crowded with cars unnecessarily stopped and the turning movements so frequent that the pedestrians cross as vehicular movements permit and pay little attention to the signals. There are also indications that the pedestrians move away from the intersection especially to the south and west and cross by jaywalking behind the stopped cars, which certainly is not a favorable symptom.

Many motorists complain of the signals, while others give their approval. A man in a nearby office says things are fine, while another says he holds his breath every time he looks out the window. Popular opinion is therefore divided. Trained observers, however, think that the balance of favor from the safety standpoint lies with the signs and not the signal.

The stop signs formerly stopped 29 per cent of the total traffic, all on Wright St. and none on Green St. It was computed that the signal would stop 41 per cent, but actual counts show 44 per cent to be stopped. The signal has therefore added 15 per cent of the total traffic to the number stopped. With a daily traffic of 12 000 vehicles this means 657 000 additional stops per year.

Tests indicate that a stop costs a motorist in actual operating costs about 0.2 cent (Civ. Eng. Vol. 5. No. 5, May 1935). The 657 000 additional stops have therefore added $1300 per year to the operating costs through the intersection. The question is, what do the motorists get for their money?

The average stop at the stop signs was only 5 seconds, with only a few reaching 20 seconds; the maximum recorded was 26 seconds. With the signal, however, the average length of stop on Wright St. involving 22 per cent of the total traffic averages 23 seconds, or 4.6 times as much as formerly. This may be of interest to those people who insist that the signal lets them enter more quickly than the signs.

On Green St., where stops were formerly rare, about 21 per cent of the total traffic is stopped for an average of 10 seconds. The maximum stop on both streets is about 2 seconds longer than the red interval of 18 and 40 seconds and occurs with great frequency. The average stop on both streets is about 60 per cent of the red indications.

If the average of 5 seconds for a stop as formerly required by the signs is taken as a normal stop length, the signal has added an average of 18 seconds of waiting time to stops on Wright St., and 5 seconds to those on Green St. Combining these figures with the number of stops and a daily traffic of 12 000, the total waiting time, or delay, amounts to the nice figure of practically 1000 car-minutes, or 16.8 car-hours per day.

Some highway economists claim that this time can be evaluated at the rate of 1 cent per car minute. This gives the interesting figure of $10 a day, or $3650 per year. Whether this is valid or not, it is a fact that this delay is part of the trouble with pedestrian crossing.

You may each draw your own conclusions as to how well this signal is performing its sworn duty of facilitating traffic and promoting safety, and as to whether compliance with the minimum warrants as the justification for this signal is, or is not, good traffic engineering.

It may be asked, how can it be foretold as to what is likely to happen in cases like this. A properly trained and capable traffic engineer knows how to make and analyze suitable studies and forecast the results. This very intersection was the subject of some studies by a graduate of this University who incidentally is now employed by the Division of Highways. Part of his work appeared in the "Technograph" April 1933 and it is really surprising how accurately he forecast the very things which later records have shown to have taken place. More records following an installation would be a check of inestimable value, but generally all such studies are forgotten when the signal is put into operation.

Leaving the time-cycle signal, let us turn to the traffic-actuated type, again assuming a simple intersection. Such signals are of two varieties, the semi-actuated and the full actuated, and we will consider the semi-actuated first.

Contact pads are placed in the pavement on the minor street at suitable distance from the intersection. The green indication is normally given to the major street but when a car crosses a pad an impulse is sent to the controller which then changes the indication to the minor street. After a definite minimum interval a recall switch returns the green to the major street unless a second car crosses the pad in the meantime. This second car will actuate a time extension switch which will add a definite amount to the green indication starting at the instant of crossing the pad. Additional cars will do likewise until the interval is built up to a fixed maximum, and then the recall switch will return the green to the major street, where it will remain for a definite minimum time before it can again be displayed to the minor street. To provide for cars on the minor street that have been stopped by the signal a memory relay holds the call until the expiration of the minimum interval on the major street, and then gives the right of way to the minor street.

In this way the length of the green indication on the minor street varies between a fixed minimum and a fixed maximum. On the major street the green indication varies from a fixed minimum to an indefinite maximum depending on calls from the minor street. This type of signal is very effective where a major street must be interrupted for a minor one, or where there is wide fluctuation of movement on the minor street with fairly sustained traffic on the major.

The timing of such a signal is quite different from that of the time-cycle, but is not difficult if adequate data are available. Minute-by-minute traffic counts are especially useful in working out proper timing.

The distance to the contact pads is important. It should be such that a car traveling at a normal approach speed will not be required to unduly reduce speed if it gets the signal immediately on crossing the pad. Arbitrary fixed distances should be avoided, and since speeds may vary in the separate approaches the distances may not be equal in all directions.

The minimum time set for the minor street should allow for cars stopped at the signal to start and clear the intersection. The time extension, or vehicle interval switch, should be set for the time it takes for a car traveling at the normal approach speed to move from the pad into the intersection. This interval is therefore dependent on the pad distances, the speed, and the width of the intersection. It should not be too long, hence the tendency should be to reduce it below that indicated, especially if the minute-by-minute counts indicate that cars do not follow in large groups.

The minimum time on the major street should be just enough for the cars accumulating during the normal average stop period, and should tend towards being short rather than long. The maximum period on the minor street is governed by the frequency of cars on the minor street, and should be fairly long to accommodate the occasional string of cars that may approach. It should be remembered that it is desirable to interrupt traffic as little as possible.

The full-actuated differs from the semi-actuated in that pads are placed on both streets. Each street then has minimum, maximum, and time extension switches and a memory relay. There are no recall switches, or, if present, they are normally turned off, since the recalls are made by the memory relay or by a new actuation caused by a vehicle crossing the pad on the opposing street. The green indication thus remains with the last street having it if the memory switch is not actuated until a call comes from a vehicle crossing a pad on the other street.

This type of signal is suitable for use at the intersection of two major streets where wide fluctuations in traffic occur on both. Minute-by-minute traffic counts will show that wide fluctuations often occur on heavily traveled streets of apparently sustained traffic flow.

The traffic limitations as given for the time-cycle signal do not fully apply to the actuated types, and no satisfactory limits have yet been worked out. In case an application is made for a signal where the limits do not approach those set for the time-cycle signal, it may be worth while to study the possibilities of an actuated type. The actuated type has many advantages over the time-cycle type for it is adaptable to variable conditions which the time-cycle type cannot adequately handle. Its greatest disadvantage is its higher cost of installation and upkeep.

From the foregoing it should be clear that the determination of whether a signal should be installed, and what type should be used, goes far deeper than a casual inspection and a few superficial traffic counts. It demands something more substantial than a request from a chamber of commerce, a resolution by a service club, a popular petition, or a howl by an editor. It is also evident that the timing of the signal is more intricate than twisting a few dials, turning on the juice and letting her go. The determination should be made only by an engineer trained and experienced in collecting and interpreting the proper data. He should have the right attitude, keen powers of observation and analysis, a high degree of technical knowledge, a generous supply of diplomacy and an enormous amount of intestinal fortitude.

Such a man will invariably apply the rule: "When in doubt, leave it out."

XII. THE RELATIONSHIP OF HEADLAMPS TO ROAD SPEEDS

W. C. GIESSLER*

Each state in the Union has its own traffic laws and these various laws all differ to some extent. This lack of uniformity is undesirable, so in 1925-26 the National Conference on Street and Highway Safety prepared and adopted a Uniform Act Regulating Traffic on Highways and recommended its adoption by all states. This Act was revised in 1930 and again in 1935.

Governor Henry Horner realized the advantages of uniform traffic regulations, urged the State Legislature to enact legislation of that nature, and requested Mr. Ernst Lieberman to prepare a bill for presentation to the Legislature conforming with the Uniform Act recommended by the National Conference.

The present Uniform Act Regulating Traffic on Highways was prepared by the Division of Highways and enacted by the Legislature at the regular 1935 Session. Governor Horner signed the bill, making it law on July 9, 1935. Article XV, Section 123 of this Act reads as follows:

"The Department shall adopt a manual of rules and regulations governing the operation of Official Inspection Stations for the inspection of brakes, lighting equipment, steering mechanism, horns, mirrors, windshield wipers and other equipment of motor vehicles, trailers, and semi-trailers. Any public garage having complied with the Manual of Rules and Regulations adopted by the Department, as herein mentioned, shall be recognized as an Official Inspection Station."

Mr. Lieberman assigned the preparation of this Manual of Rules and Regulations to the Bureau of Machinery, in which I am an engineer and the actual work of preparation was assigned to me.

The Uniform Act, as adopted in Illinois, does not carry any specific requirements for the aim or intensity of headlamps. In the Manual, we incorporated a requirement so worded that we might become more specific in our inspections as research or other sources of information provided reliable data. The provision in the Manual reads as follows: "Light beams must not be aimed so high that they blind an approaching driver, or so low that a vehicle or object 200 feet ahead will not be illuminated."

We made no provision whatsoever for intensity, because at the

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time the Manual was written there was only one instrument or device on the market which calibrated lamp output or beam candle power.

Last spring, a tester which could be used for testing aim and intensity was placed on the market. This tester could be used on the highways, as well as in the garage, so we secured one of these testers and inaugurated a series of practical night headlamp tests.

South of Springfield, the modernization of a section of Route 66 left a 1000-foot straight level stretch of 16-foot concrete practically unused, although open to traffic. This pavement was marked off at 50-foot intervals for the test. Five different automobiles were used. They were a 1935 Ford, a 1936 Oldsmobile, a 1936 Pontiac, a 1936 Chevrolet and a 1934 Studebaker. Arrangements were made so that the lamps on these automobiles could be adjusted for various vertical aiming positions and for various light intensities or beam candle powers. Observations were made on three pedestrians; one dressed in dark clothes, another in gray, and a third in white.

The standard procedure for the vertical aiming of headlamps is to use the pattern of the intense beam or so-called "hot spot," and locate it on a screen 25 feet ahead of the lamp so that the top of the "hot spot" is a certain distance above or below a line level with the center of the lamp itself. For side aim the center of the "hot spot" is located with relation to the prolongation of the center of the lamp.

In accordance with this procedure, the lamps were arranged so that observations could be made with beams aimed 4 inches above level, 2 inches above level, level, 3 inches below level, and 6 inches below level.

By inserting a variable resistance in the lamp circuits, the total light intensity of two lamps could be changed from a maximum of 25 000 beam candle power to a minimum of 5000 beam candle power.

By these methods we were able to take observations with excellent headlamps and with all other grades, down to very poor. The three pedestrians walked out into the dark zone beyond a point at which they were visible to the observer seated in the driver's seat. They then walked along the edge of the pavement toward the observer until he recognized them as pedestrians, when he signalled them and they reported their distance from the lamps of the automobile and observer. Observations were made on the three pedestrians for five aiming positions and five intensities from five different automobiles. Curves for each intensity and pedestrian were plotted for each automobile and these were then replotted as composites, using distances as abscissas and aiming positions as ordinates. Other composite curves were

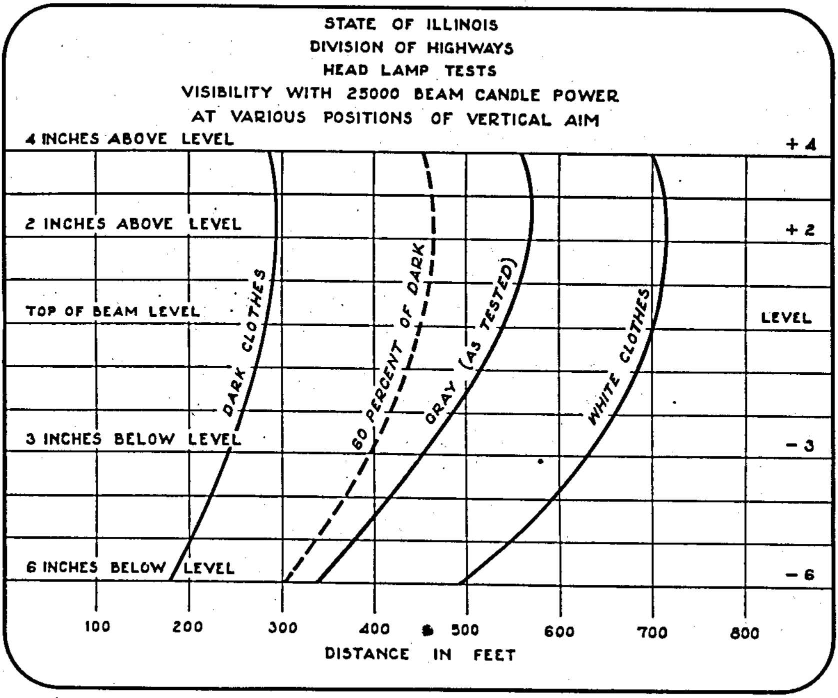

FIG. 1. VISIBILITY OF PEDESTRIAN WITH 25 000 BEAM CANDLE POWER AT VARIOUS POSITIONS OF VERTICAL AIM

plotted using distance as abscissas and beam intensity as ordinates. These curves are very interesting. You will notice that the maximum visibility, or we might say "reach out," was obtained with lights set 2 inches above level. This distance was 715 feet for a pedestrian in white, 570 feet in gray, and 295 feet in dark clothes, with a beam of maximum intensity. With the beam of the same intensity lowered to 6 inches, the visibility on white was reduced from 715 to 490 feet, on gray from 570 to 335 feet, and from 295 to 180 feet on dark clothes, an average reduction in visibility of 36 per cent.

Now let us look at the composite curves for beams of minimum intensity of 5000 beam candle power. The maximum "reach out" was at high aim positions. The pedestrian in white was visible at 510 feet, in gray at 365 feet, and in dark clothes at 165 feet. With a beam of the same intensity lowered to minus 6 inches, the visibility on white was reduced from 510 to 300 feet, on gray from 365 to 225 feet, and on

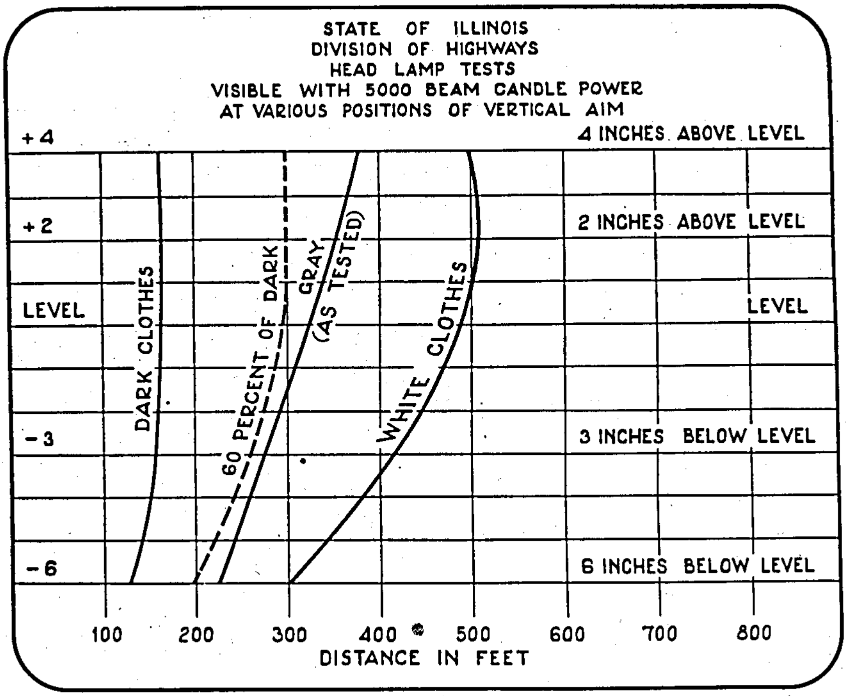

FIG. 2. VISIBILITY OF PEDESTRIAN WITH 5000 BEAM CANDLE POWER AT VARIOUS POSITIONS OF VERTICAL AIM

dark clothes from 165 to 125 feet, an average reduction of 37½ per cent.

Now let us compare the visibility of a 25 000 candle power beam with that of a 5000 candle power beam. The maximum visibility of the stronger beam was 715 feet on white, 570 feet on gray, and 295 feet on dark; that of the weak beam was 510 feet on white, 365 feet on gray, and 165 feet on dark, or an average reduction of 34 per cent.

We see from this that poor aiming may reduce the visibility to 64 per cent of maximum and poor intensity may reduce it to 66 per cent, and a combination of both may reduce the visibility to 64 per cent of 66 per cent, or to 42 per cent of a possible maximum.

Let us check these values on the white-clothed pedestrian. We find that the maximum visibility at aim plus two and intensity 25 000 was 715 feet and the visibility when the aim was reduced to minus six and intensity to 5000 was 300 feet, or 42 per cent of 715 feet.

The relative efficiency of the passing or depressed beam is interest-

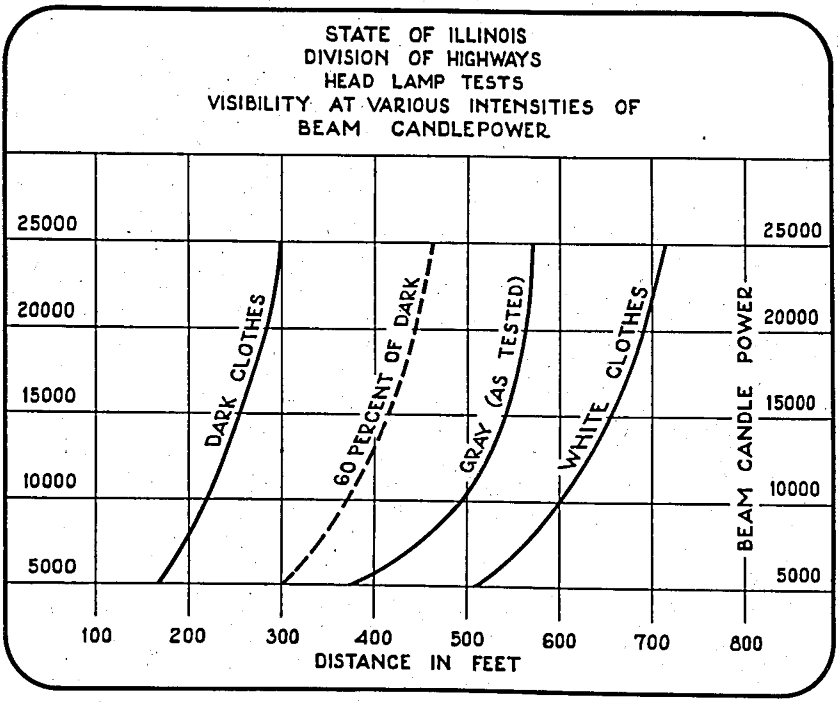

FIG. 3. VISIBILITY OF PEDESTRIAN AT VARIOUS INTENSITIES OF BEAM CANDLE POWER

ing. We found that the average visibility by the passing beam was 55 per cent of that of the driving beam, nearly the same as the relationship between good lights and poor lights.

An interesting angle of these observations was discovered in connection with an old hay rack. We placed a typical old weather-beaten hay rack on the pavement and approached it slowly with bright or driving lights, and found that it became visible at 365 feet. With the passing beam it became visible at 206 feet, which indicated a passing beam efficiency of 56 per cent of that of a driving beam, checking our figure of 55 per cent.

We then investigated the effect of approaching lights on visibility. A car facing the observing car was placed alongside the hay rack and its passing beam was switched on. The visibility of the observer was reduced from 365 to 173 feet, or 56 per cent. When this approaching beam was changed from a passing to a driving beam, the visibility was reduced to 150 feet, or 59 per cent. You will notice the small difference between the effect of an approaching bright beam and a

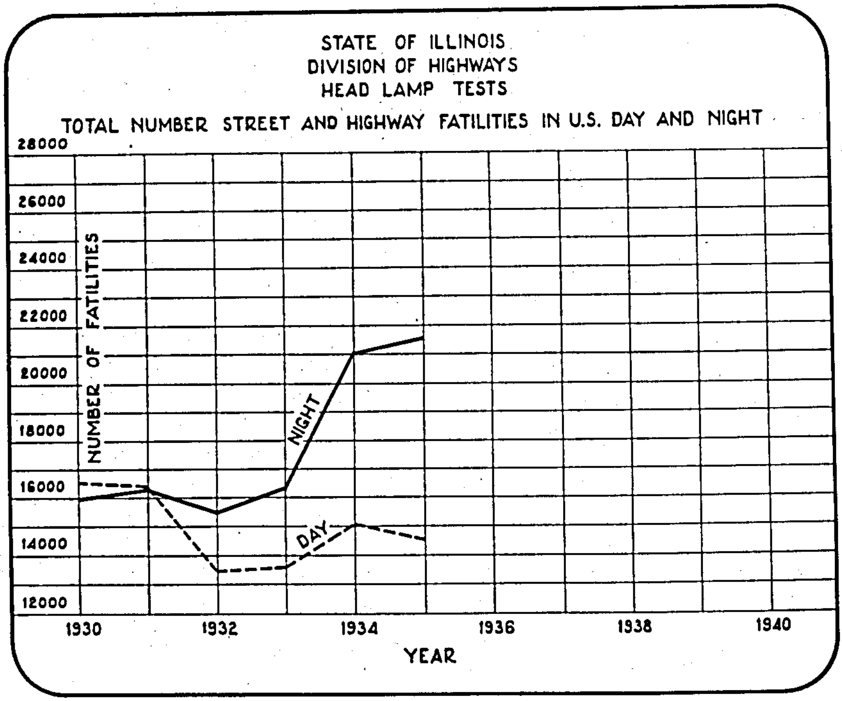

FIG. 4. NUMBER OF STREET AND HIGHWAY FATALITIES IN UNITED STATES FOR THE YEARS 1930-1935, DAY AND NIGHT

passing beam, and we believe that this condition may be due to the fact that glare is caused largely by stray light and that it is approximately the same for a properly aimed driving beam and for a passing beam. Inasmuch as these results were obtained from a single observation, we plan to conduct more extensive experiments on glare.

The fundamental object in all this business of vehicle inspection is the reduction of the accident rate. Statistics show that from 1932 to 1933 the night fatality rate increased 5 per cent and the daytime rate 1.2 per cent. From 1933 to 1934 the night increase was 23 per cent and the day increase 11 per cent. From 1934 to 1935 the night increase was 2 per cent and there was an actual decrease of 3 per cent in the day rate. You will notice that the night trend is upward and the day trend is downward. We believe that headlamps are largely responsible for this trend, and present herewith a graph which clearly shows the relationship between visibility and driving speeds.

We have assumed that at night it will require two seconds for the

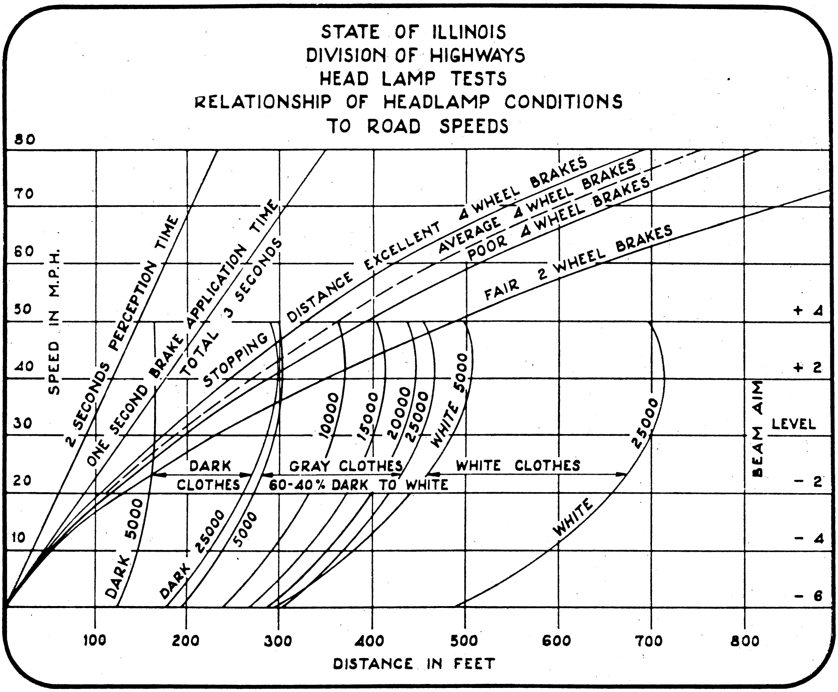

Fig. 5. Relation Between Permissible Road Speeds and Headlamp and Brake Conditions

average driver to perceive an object in his path of travel and one additional second to apply the brakes. These times we have called "perception time" and "brake application time." To the right of the three second time line we have laid off the distances required to stop a vehicle from various speeds, and have plotted curves for excellent four-wheel brakes, average four-wheel brakes, poor four-wheel brakes, and fair two-wheel brakes.

From these curves, we find that if the lights are good, and anything that might get in the way is colored white, we can drive as fast as 80 miles per hour with excellent brakes, but such conditions are rare. However, a pedestrian in dark clothes could be seen only 300 feet ahead, which would permit a speed of only 47 miles per hour with good lights and good brakes.

But what about the car on which the aim was lowered to minus six? This same dark object would only be visible at 180 feet which would allow a 31 mile speed with good brakes, or a 27 mile speed with poor four-wheel brakes. If the aim was set at a good position, say plus two, but the intensity was reduced to 5000 beam candle power, then a dark object would be visible at 165 feet, allowing a road speed of 29 miles for good brakes or 27 miles for poor four-wheel brakes. A combination of poor aim and poor intensity on a dark object would reduce the visibility to 125 feet or the allowable road speed to 23 miles per hour for good brakes, or 22 miles per hour for poor four-wheel brakes.

And now let us see what the effect of oncoming lights or glare is on safe road speeds. In our experiments with an old hay rack, we found that such an object became visible at 365 feet with good lights, which would permit a road speed of 54 miles per hour with good lights, but this visibility was reduced by oncoming dim or passing lights to 173 feet, permitting a road speed of 30 miles per hour. Oncoming bright lights reduced this visibility to 150 feet or a safe speed to 27 miles per hour. Bear in mind that all this time the driver has been using a good driving beam. If he should be using his passing beam and meet a car with a driving beam, then his visibility would be reduced to 83 feet or the allowable road speed to 15 miles per hour.

The question might now be asked "What is a safe driving speed?" There is no accurate answer to that question, but we might make a technical guess by making a composite of all of the foregoing results. Assume the following: (1) that our total reaction time under night driving conditions would be three seconds; (2) that a pedestrian, instead of being dressed in all white or all dark clothes, was clothed to afford a visibility of 40 per cent of that of a person in white; (3) that our average brakes are just between good and poor four-wheel brakes; (4) that the average lights are aimed three inches below level; and (5) that the average beam candle power is 15 000. Under these conditions, we find that our visibility distance is 360 feet, permitting a road speed of 50 miles per hour.

Another question that may naturally arise in the mind of the reader is: "What are considered good headlamps?" We have frequently referred to two inches above level as the best aiming position. That is true when we consider only the driver of the car and lamps under consideration. The driver of the oncoming car should not be overlooked. With this in mind, we do not recommend that any headlamp beam be set higher than level, and if passengers are carried in the rear seat, a setting of one to two inches below level should be maintained, because a load in the rear seat raises the beams of the headlamps and may reduce the effectiveness of the driver's own lights, as well as reducing the visibility afforded the oncoming driver.

All of these tests were made on typical summer nights under good weather conditions. Snow, rain and fog will naturally require still slower speeds for safety.

The conclusions that may be drawn from these tests are that we are without a doubt over-driving our headlights. We believe that if these facts could be impressed upon all garage service men and in turn by them upon the driving public, there would be a substantial reduction in night accidents on the highways. But we should not stop at this point. The pedestrian should be brought to realize that it is difficult for the average driver to see him unless he is dressed in light clothes. If a pedestrian would do nothing more than carry a fully opened white handkerchief in his hand while walking upon the highway at night, he would afford a greater visibility to the oncoming driver and thereby greatly enhance his own chances of arriving home safely. Persons who are by necessity required to drive horse-drawn vehicles upon the highway after dark should, for their own protection, equip those vehicles with red lanterns or a series of red reflector buttons attached to the rear of the vehicle, which would aid very materially in the prevention of night collisions. All bicyclists should be warned and encouraged to wear light clothes and provide their bicycles with effective tail lights or reflector signals.

If a systematic campaign of education was inaugurated along these lines, we believe that the upward trend of the night fatality curve could be changed within one year to a downward trend, which, with the downward trend of the daylight fatality curve would represent a material reduction in the total accidents upon the highways.

RELATIONSHIP OF HEADLAMPS TO ROAD SPEED

Color or Nature of Object	Beam Aim	Beam Candle Power	Object Is First Seen at	Maximum Permissible Speed With Average Four-Wheel Brakes—M.P.H.
All white	Level	25 000	700 feet	77
	Level	5 000	490 feet	62
	−6 in.	25 000	490 feet	62
	−6 in.	5 000	300 feet	49
Average Gray	Level	25 000	450 feet	58
	Level	5 000	295 feet	43
	−6 in.	25 000	300 feet	44
	−6 in.	5 000	195 feet	31
All Dark	Level	25 000	185 feet	30
	Level	5 000	165 feet	28
	−6 in.	25 000	180 feet	29
	−6 in.	5 000	125 feet	22
Unlighted Vehicle	Level	25 000	350 feet	49
	Level	5 000	235 feet	36
	−6 in.	25 000	235 feet	36
	−6 in.	5 000	150 feet	26

XIII. THE PLACE OF PUBLICITY IN A HIGHWAY PROGRAM

James D. Adams*

The success of any well-founded state highway program rests upon coöperation of the newspapers with highway officials in keeping the motoring public informed on road conditions and problems.

A well-informed public is the most powerful support that any highway department can have for its program of highway development and improvement, while a public that is inadequately informed may easily become a serious handicap in the accomplishment of that program.

Why should not the public be informed on every phase of highway planning, construction and maintenance? Every employee of the state highway department is working for the motorist. The motorist pays the bills and certainly has every right to know how his employees propose to spend the money he pays in gasoline tax and motor vehicle license fees for operation of this highway system.

I do not feel that there is any dollar the taxpayer spends for which he gets a greater return than the dollar he spends for road construction and maintenance. Few motorists realize that they pay the equivalent of what good highways would cost over inferior ones, in the increased depreciation of their cars or trucks and in higher operating costs.

You will remember when only a few years ago owners of passenger car fleets allowed their salesmen mileage costs ranging from seven to eleven cents per mile. That was in the days of no gasoline tax—and inferior highways. Today the mileage allowance is frequently as low as four cents per mile—reduced because improved highways financed through the gasoline tax have made possible lower operating costs and reduced depreciation.

Thus the gasoline tax, amounting to four cents a gallon in Indiana—approximately a fourth of a cent a mile—has been responsible in large measure for a saving of from three to seven cents a mile in automobile operation by providing improved highways.

In Indiana in 1935 the average motorist, including truck owners, paid an average of $33.70 in gasoline tax and motor vehicle license fees. Half of this payment, amounting to approximately $1.38 a month, was received by the State Highway Commission to finance

*Chairman, State Highway Commission of Indiana.

construction, maintenance, and operation of the nine thousand mile state highway system.

No fair-minded motorist will claim that $1.38 a month is too much to pay for his state highway system. It is less than he pays for garage space in which to store his car, and considerably less than he pays for his automobile insurance. If Indiana motorists were relieved of the payment now being made in gasoline tax and motor vehicle license fees for their state highway system, it would take twenty-one years for them to save enough to purchase a $700 automobile. In Illinois it would take twenty-three years.

State legislatures divert highway funds and reduce gasoline taxes and motor vehicle license fees because their members are not informed of highway needs, cost of maintenance and construction, and because they do not understand what becomes of the sums paid by the motorists. We have found members of the legislature in the peculiar position of favoring diversion of funds from the highway department although they readily signed petitions for the improvement of highways and the construction of bridges on roads in their communities. When a group of state senators called upon me recently to present a proposal for the reduction of the gasoline tax, I found that not one of them knew how much the average motorist in Indiana was paying annually. When they had been shown that it was only $33.70 a year, they agreed that it was not excessive and abandoned their proposal.

We find people intensely interested in what their state highway department is doing and what it proposes to do in the future. It is important that they be acquainted with the costs as well as the progress. Not one in fifty has an accurate conception of the cost of a mile of pavement, an oil mat road, or a grade separation.

It is the policy of the State Highway Commission of Indiana to keep the public as fully informed of its activities as is possible with the coöperation of the newspapers. It would be only proper to say in this connection that without the constructive coöperation which we have received from the newspapers, our efforts to create greater motoring safety and a highway system suited to modern needs could not have been advanced so effectively.

Our publicity program provides for the sending of news releases each week to all newspapers in the state. These list projects on which bids are to be taken and describe each project, give the low bidder on each project, announce the award of contracts, describe maintenance operations, record the purchase of equipment, explain proposed improvement programs, outline safety factors in highway design and marking, and call attention to the scores of other activities involved in operation of a highway system.

In addition, a weekly report is made on all detours in effect on the state highway system, and special bulletins are issued during periods of emergency such as floods, snow, or ice, and at other times when normal traffic is impossible. Special articles on various phases of state highway activities are prepared upon request, and photographs are furnished to illustrate highway stories.

The coöperation of the newspapers in our highway program has extended beyond the presentation of this information to their readers. Many of them have written special articles about highway programs affecting their local communities, explaining policies and financial problems faced by the commission. As a result we feel that the motorists of Indiana are perhaps more thoroughly acquainted with their state highway system and its many phases than are motorists in other states where the same degree of coöperation has not made this information available through their newspapers.

You should take the editors of the newspapers into your confidence. You cannot expect them to understand your problems without your help and explanation. One of the most helpful ways to extend this assistance is to invite newspapermen to accompany you on trips to inspect construction work and to ask their suggestions on the solution of problems faced in attempting to best serve the motoring public.

If we in the highway industry, easily one of the most important phases of government today, are to properly inform the motoring public of our activities through the newspapers we must assign the task to a newspaperman. It would be as foolish to turn the task over to an engineer as it would be to ask the newspaperman to design a road or bridge.

It is essential that the highway story be told through men trained in reporting and publicity. It is not enough to gather a lot of facts and dump them on the editor's desk. They must be sifted and collected in the order of their importance, be concise yet giving all essential details, and be presented in a form that meets the newspaper requirement.

An adequate, well-conceived publicity program is as essential to a highway program as is a bridge to a highway. Operation of a highway department without keeping the motoring public advised is as out-of-date as would be a modern highway with fords instead of bridges. Modern highway needs, accomplishment of which depends increasingly upon the support of the motoring public, must be discussed fully and frankly through the newspapers and other publicity mediums to win and hold that support.

XIV. PRESENT AND FUTURE OF ILLINOIS HIGHWAYS

Ernst Lieberman*

In addressing an audience as intimately connected with road development as this one, it seems wholly unnecessary to dwell on the subject of the present status of Illinois highways. Most of you have been actively engaged in the task of improving our highways, many of you for a considerable period of time, and you know as well as I do how far we have come. For the purpose of the record, however, it may be appropriate to briefly summarize our present position.

There are approximately 102 520 miles of public roads in the State, excluding streets in municipalities. I might mention that for a number of years we have been working under the impression that this figure was about 97 000 miles. However, our State-wide planning survey has discovered a number of local roads not previously mapped, and as a result our highway problem has assumed even greater proportions.

To the end of 1936 the State and counties together had improved 16 043 miles of road with surfacing. Of this total 12 636 miles were of high-type pavement, 382 miles of medium-type bituminous surfaces, and 3025 miles of gravel or crushed stone. Of the total the State had constructed 10 953 miles, 10 347 miles on the primary system, 591 miles on the secondary system, and 15 miles of miscellaneous classifications. The counties had built 5090 miles of the total as 15d or M.F.T. improvements.

There are 12 609 miles of unsurfaced State-aid roads. These are under the maintenance and control of the counties, and are eligible for improvement by the counties, and to some extent by the State, under the Federal aid secondary road program.

There remain 73 868 miles of local roads under the jurisdiction of the townships and road districts. We have no reliable records at the present time of the extent to which these roads are improved. While some have been surfaced, and while this work has gained impetus recently through W.P.A. assistance, we know that a great majority of the township roads are as yet unimproved.

With this sketchy picture of our present highway situation, we will turn to the other division of my topic, that of the future of Illinois highways.

I think we will never reach the stage where highway development has caught up with the needs of the day. I should like to quote a

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paragraph from the book "Chicago's Highways—Old and New" by M. M. Quaife, which expresses this thought:

"Like death and taxes the demand for better highways is omnipresent. Leaving the Indian out of account, it began with the advent of the first settler in the wilderness, and has continued to the present moment. Nor is it to be expected that completion of any highway program now under contemplation will permanently solve the problem, for in any progressive society the existing standard of highway achievement will ever be made the starting point from which to measure new advances."

His remarks about the demand for better highways being omnipresent leads me to believe this writer may have been watching my daily mail.

Assuming we are always to have the demand for more highway improvement, the question of the future resolves itself largely into one of financial ability. And on that point I think we as highway officials and engineers can do much to encourage straight thinking on the part of the layman, and probably do a little on our own account. Our newspapers carry stories of large amounts of money collected in license fees and gasoline taxes and deposited in highway funds. Articles emanate from Washington telling of large allotments of Federal funds for highway work. In fact, a single allotment is generally good for several press releases at intervals, and the reading public may easily get the impression that each story refers to a new apportionment.

But even if the layman is able to get his figures straight on revenues, his ideas of where these funds go is likely to be pretty hazy. His thoughts will probably be something like "$60 000 000 is a lot of money for the State to put in hard roads in one year." When reminded of the fact he will probably recall that some highway funds have been diverted, that the State does not get all of the gas tax but shares it with the counties and cities, that there are some obligations on outstanding bonds which must be met, that maintenance and policing cost something, but even then he is apt to end up with a construction fund considerably larger than it actually is. It is our duty to impress on the public mind the true picture of highway financing.

We expect that motor license fees during 1937 will total about $19 000 000, but approximately $1 000 000 of this will be required for operation of the State Automobile Department. Providing the present basis of fees is continued, we could probably reasonably expect some increase during the next few years. It would probably be safe to assume an average of $19 000 000 annually after deducting cost of operating the Automobile Department. Motor fuel tax collections will probably amount to about $35 000 000 per year, but refunds for non-taxable uses of gasoline and cost of administering the tax will reduce this to about $33 000 000. Of this balance two-thirds, or $22 000 000, will be allotted to the counties and cities. The Division of Highways will therefore have from both funds about $30 000 000 per year.

From this annual revenue we must first take sufficient for payment of principal and interest on state highway bonds, which will average about $9 500 000 annually, over the next several years. Maintenance expense will probably average $5 750 000 and policing $1 500 000; 15d refunds to counties will average $1 250 000. Highway planning, maintenance and operation of garages, administration, engineering, testing and equipment, and other miscellaneous expense of the Division of Highways will require about $4 000 000 per year. These several items total $22 000 000, which must be charged against the $30 000-000 annual revenues. From state funds we will therefore have a balance of $8 000 000 per year for construction. Assuming that Federal aid will be continued on about the same basis as has been established for this year and next, $6 250 000 will be required for matching Federal funds, which will leave $1 750 000 for straight state construction. On the present basis we would receive $9 000 000 in Federal funds, which, together with the State's matching funds, would provide a Federal aid construction program of $15 250 000. Adding to this the $1 750 000 straight state funds we find we would have a total of $17 000 000 per year for construction.

In this connection it might be well to mention the various proposals for reduction in automobile license fees. Numerous schemes of this sort have been advanced and apparently their proponents are all under the impression that the present scale of fees is rolling up huge highway construction funds. One bill recently introduced in the Legislature would reduce the annual fees on all passenger vehicles to a flat $5.00 charge. During 1936 the total fees collected were $18 895 501. Of this $12 343 580 were fees on a total of 1 459 195 passenger vehicles. All of the balance represented fees on trucks, tractors, trailers, and chauffeurs' and miscellaneous fees. If the rate on these passenger vehicles had been $5.00 the total registration fees for passenger vehicles would have been only $7 295 975 and the total fees from all classes of vehicles would have been $11 599 526. After paying principal and interest on bonds this would not have left enough funds to maintain our highways, let alone meet the various other charges. If we should revise the estimates I gave you a few minutes ago on highway funds for the next few years to the basis of a flat $5.00 passenger vehicle fee, the total revenue of the Division of Highways, including gas taxes, would be reduced to $23 000 000. Taking from this the charges for other than construction purposes we would have only $1 000 000 left. This would fall far short of matching Federal aid, so we would also lose the bulk of future Federal aid allotments. We could, of course, by neglecting maintenance, discontinuing policing and county refunds, reduce the charges for other than construction purposes. However, it seems to me this would be nothing short of folly.

The passenger car fee in Illinois is not unreasonable. It averaged less than $8.50 in 1936. The highway is one of the essential factors to motor transportation, and it costs the individual motorist much less than any other. I believe any scheme to reduce fees will gain little support from the average motorist when he realizes it will not only seriously curtail further improvement of State highways in the future, but that it will also jeopardize the investment already made and for which he is going to continue to pay for the next twenty years.

But let us assume that the license fee basis will not be disturbed, and the State will have about $17 000 000 annually to put into construction during the next several years. How are we going to spend it? Let us first consider the primary road system. With the exception of a few gaps our bond issue system is completely paved. That system has been augmented by addition of certain highways as Federal aid routes, of which part are already improved, part are under contract, and others are projected for the future. This process of taking more roads into the primary system cannot go on indefinitely, of course, and I think we will reach the point in the near future when that system will become more or less stabilized, and all of our primary road funds will be confined to that established mileage. I believe we will then find that the cost of needed widening, modernization, additional facilities such as grade separations, and the continuous development of the system will just about balance the primary road funds available.

Among the new roads added to the primary system we have already reached a number which will not have sufficient traffic to justify surfacing with pavement. In these cases we plan to build gravel or crushed stone surfaces, to be followed in a year or two with black top. Some communities seem to have the impression that when the State takes over a road it is obligated to pave it and seem quite indignant when we propose medium type surfacing. We attempt to apply sound economics to the selection of surface types, and do not propose to pave a road unless it will carry sufficient traffic to warrant the greater investment.

For a number of years the secondary road was considered the sole responsibility of the county. Improvement and maintenance was first financed by county highway taxes; then one-third of the gas tax was apportioned to the counties, and this considerably accelerated secondary road construction. However, many of the less populous counties did not have sufficient funds to make any appreciable headway, and in many localities the secondary road still remained a serious problem. During the past four years the State has been able to assist in improvement of secondary roads by use of funds allotted by the Federal government. I mentioned before that we have completed 591 miles of surfaced secondary roads, and a number of others have been graded and drained.

In its authorizations for the next two years the Federal government has included an appropriation for secondary roads. It is believed that this will become an established policy in Federal aid, and that such apportionments will continue in the future, Illinois has been allotted $1 047 760 for the current year which it must match with State funds. Next year's fund will be about the same. The State will therefore have a little more than $2 000 000 to put into secondary road improvements in each of the two years, and will probably have about the same amount available in succeeding years.

In selecting the secondary roads it will improve, the State will be guided by facts developed by the State-wide planning survey. A Federal secondary system will be established, and future expenditure of funds will be confined to roads in that system. As improvement of this system becomes completed, it can be enlarged. Because the work of the planning survey is not yet complete this system cannot be determined at once, and it is possible that this year's construction program may be formulated in advance of the designation of the system.

In my remarks on financing I estimated about $22 000 000 of gas tax would be allotted to counties and cities annually for the next several years. Half of this goes to the counties, but deductions are made for principal and interest payments on the two relief bond issues. These payments will average about $3 500 000 per year until 1943, so the counties will have about $7 500 000 available for highway work annually. Please note that the counties will have almost four times as much funds as the State will have for secondary roads. While the State will be assisting in the future, the secondary road still is first the responsibility of the counties.

While my subject concerns only the present and future, I would like in conclusion to make a few remarks on the past. We have just come through a very trying period. To meet the difficult economic conditions it became advisable to divert part of our highway revenues to other purposes. However, we are fortunate that diversion was not carried nearly as far in Illinois as it was in many other states. In spite of the loss of some of our revenues we have been able to carry out a very worthwhile highway improvement program, which in itself has been a contributing factor to recovery. I feel that we can take a great deal of satisfaction in our accomplishments of the last few years.

XV. SUGGESTED CHANGES IN THE ILLINOIS ROAD LAWS

J. Colby Beekman*

The subject assigned to me precludes a very extensive review of the history of Illinois Road Laws, and such a review would be of no especial benefit, having but little bearing upon any of the suggested changes at the present time. Prophecies of future changes would be equally futile. It is generally considered that Federal interest and financial assistance in the construction of secondary roads will continue. If this be true, the Road Laws, in some of the sections, at least, will doubtless be very materially changed to simplify administration and to more clearly define responsibility. There is also an idea prevalent among W.P.A. officials, so I am unofficially informed, that that branch of Federal Government will continue for some years, and that Federal authorities are considering a revamping of the present rather complicated set up which will place the funds allotted more or less under the supervision of the Division of Highways. If such an arrangement is made the present Road Laws affecting counties and townships or road districts probably may be adequate.

President E. L. Gates of the Illinois Association of County Superintendents of Highways has just concluded a series of meetings throughout the State in which there were several changes suggested in the existing Road Laws. These suggested changes have been fully discussed, and the Legislative Committee of the Association prepared a digest of the discussions on which its recommendations were based. At the meeting held yesterday the report was submitted to the Association, and the following proposed changes in the Road Laws were approved:

(1) In some of the counties in the southern part of the state particularly, salaries paid to county superintendents are very low, not being in line with those paid other county officials where fixed by statute, and a scale based on population, worked out after exhaustive research by Mr. Van Tarbel, Superintendent of Highways of Clark County and a sub-committee, will be incorporated in a bill which the Illinois Association of County Superintendents of Highways will unanimously support.

(2) A proposal was presented to amend the Road and Bridge Laws to allow counties that have their entire State-aid system improved, to increase their mileage along lines proposed in a bill drawn by Claud

*County Superintendent of Highways, Menard County, Petersburg, Ill.

Hanson of Kane County and introduced by Senator Arnold P. Benson in 1935.

A conference with Mr. Lieberman developed the fact that the Highway Department was contemplating a bill for the increase of mileage in counties to comply with Federal regulations in the allotment of funds for the improvement of secondary roads, and the Association approved the recommendation of the Legislative Committee that we will support the bill and do all in our power to promote its passage.

(3) It has been suggested that the Motor Fuel Tax Law be amended by adding an additional *one cent* to be distributed by giving (a) enough to the State to meet its Federal Aid Allotments for secondary road improvement and (b) the balance of the increase to counties for secondary road improvement.

In view of the fact that bills have been introduced reducing the license fee, this is a proposal which requires much study, and, to get proper and adequate support for a bill proposing such an increase, a thorough study must be made and a comprehensive tabulation of financial statistics must be prepared.

(4) The numbering of roads in the County system has been discussed in the various district meetings, and the recommendation of the committee was that action be deferred until the planning survey is completed, from which a numbering system can be developed.

President Gates appointed a committee composed of Walter C. Dye of Vermilion County, Alex Anderson of Ogle, and B. C. McCurdy of St. Clair to coöperate with Mr. Baker and Mr. Harrison in working out such a plan.

(5) An amendment to the present law covering the issuing of bonds by counties for highway purposes. At present counties under *township organization* can issue up to 5 per cent of county valuation, while counties under commission form can issue *only* 2½ per cent. We propose to seek an amendment allowing counties under the latter classification to issue 5 per cent, the same as the counties under the first classification.

(6) An amendment to Sec. 50 Chapter 95½ of the Motor Vehicle Act of 1919 to read as follows: "The Road Fund shall, if and when the State of Illinois shall incur any bonded indebtedness for the construction of permanent highway, be set aside and used for the purpose of paying and discharging annually, the principal and interest on such bonded indebtedness then due and payable, and for no other purpose, and the surplus, if any, after the payment of principal and interest on such bonded indebtedness then annually due, shall be used

first to pay the cost of administration of this act, and secondly, *of the balance one-half shall be used by the Department of Public Works and Buildings//and the other half shall be allotted to the counties of the State as follows: first, to each of the one hundred two counties in proportion to its motor license fees and, second, to those counties entitled to refunds in accordance with the provisions of Article IV, Section 15-D of "An Act to Revise the Law in Relation to Roads and Bridges" approved June 27, 1913, as amended. Provided, however, that until the indebtedness of the State shall be paid, not less than fifty per cent per annum of the one-half allotted to the counties shall be used in the payment of refunds."*

The Committee recommended that the proposed bill be introduced subject to approval or changes to be suggested after conferences are held, and this recommendation was approved.

This constitutes the legislative program which the Association proposes to sponsor, but, of course, there are some bills already introduced that we consider as being against a progressive comprehensive highway program, and there probably will be others of the same sort thrown into the legislative hopper; the Illinois Association of County Superintendents of Highways will resist the passage of all such bills.

XVI. STATE PROGRESS AND HIGHWAYS

F. LYNDEN SMITH*

In less than a century and a quarter Illinois has risen to a commanding position among states. In government, in its business structure, in its modern educational system, Illinois is a leader.

Our state of civilization is advanced, our culture on a high plane. Many other states with which Illinois is now on an equal level required twice as long for the building process. It should be a matter of great pride for our citizens that though Illinois' development has been swift, it has been substantial, and each year continues to add to the happiness and welfare of our people.

We who are engaged in the building of highways know that the development of transportation has gone hand in hand with the history and progress of civilization. With the surmounting of each natural barrier and the carrying farther westward of pioneer culture and ideals, there was further stimulation to new development.

As Illinois progressed, so has the history of our highway system been written. Or should I say, as road building progressed so the state's annals of achievement grew.

The economic and social benefits of public highways touch every phase of community life. There is no way to measure the full benefits, yet we know from early American roads that destinies of cities have been advanced or hindered by roads. Look to the Cumberland Turnpike built in the early years of the nineteenth century from Cumberland to Wheeling. It became a great and popular thoroughfare, and early travelers reported the road crowded with wagons. As travel on the road increased, Baltimore and Philadelphia benefited mightily, and New York temporarily lost ground in the fields of trade and industry. New York merchants, however, had other transportation facilities in view, but for a time the Cumberland road swayed the development and growth of all communities near it.

There is not a phase of American life today that is not affected directly or indirectly by improved roads. In the early days, roads played an important part in the settlement of Illinois. There is little need for me, however, to recount for you the successive changes from the time our state was dotted with small settlements in the wilderness to the present day with our cities, our industrial centers, and our farming sections all linked by a network of roads that make them

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accessible for the movements of trade or the pleasure jaunts of our citizens.

Our problems are different, perhaps greater, and certainly more complicated than were those of the road builders of a century ago. We know that our road building program must be a visionary one, based upon our present system and the probable needs of generations to come.

I like to think of the road builders' work as on a level with that of our lawmakers who are looking to the needs of our people from year to year, sponsoring legislation for the increased happiness and welfare of our citizens. I like to believe that the road builders' work is as necessary and as important to the continued development of our state as that of our educators who direct the learning and molding of young Americans preparing themselves to take the reins of government, business, and other lines of activity. It is reassuring to know that Illinois' system of roads has played an important part in the building of our great industrial centers and in the extension and strengthening of the state's business structure generally. It is an incentive to continued and thoughtful development of our highway system to realize that the full economic returns of a network of pavements such as Illinois has are so great they are incapable of adequate measurement.

It is important that road builders continue to consider the service they are rendering our citizenry in a social way, offering to urban dwellers the respite from the intensity of the city in making accessible to them the wide-open spaces of the state—our state parks and our historic monuments—and in bringing the cultural advantages of the city to the rural resident.

With this comprehensive picture of the effects of our present-day road building and planning on future generations, we are charged with a big task. Our highway planning survey will give us a broad picture of the priority of development of roads on a basis designed to serve our needs adequately. Modern designs, adequate grade and railroad crossing protection, safety measures, both those inculcated in our road building and in an educational program for motorists, extension of the roadside planting program from esthetic, maintenance, and safety angles are important points of consideration in carrying out our road building program.

It is my conviction that Illinois road builders of today will contribute an important part, and a part of which we may be proud, to the development of our highway system, leaving for our successors a well defined program of activity. You are alert to the problems ahead and you are facing those problems squarely, observing what other states are doing, looking to the new and incorporating the best from all of your findings in the Illinois program. The short course you are now attending acquaints you with all the phases of modern highway building, giving you a picture of the specific subjects and helping you to broaden your own specialized work through an intelligent understanding of the whole.

I need not tell you that the sound economic position to which Illinois has risen has a direct bearing on the construction of roads. A few years ago the state was hopelessly in debt. Bills had piled up and the solution looked hopeless. Our state could not borrow money, or when it did was forced to pay excessive rates of interest. When Governor Horner took office, he took hold of the situation with a determination to restore the state's credit and place its government functions on a business basis. He exercised rigid economies, cutting out waste and instituting modern business practices in the departments under him. Today, you know the story. Illinois is operating under a balanced budget. Despite the tremendous emergency problems which had to be met, the state is on a sound financial footing. Its credit is second to no other state in the union.

All the agencies with which the highway department deals have benefited correspondingly. Contractors are able to chart their business operations, knowing that estimates will be paid promptly when due. No longer are there delays occasioned by the state's inability to meet its obligations.

With the state on a sound financial basis, the highway department is operated in accordance with approved business practices. Because my training and experience have been in business, I appreciate and understand the problems of the contractor. I believe he is entitled to a fair profit for a piece of work well done, whether it is for the state or for a private agency. And because of the harmonious relations between the department and the contractors, the latter have come to a fuller appreciation of the state's problems.

Coöperation of county superintendents of highways and the state highway division has enabled us to pursue an economically and technically sound program, as well as a popular one. The long range picture which the state body has of the needs of the system and the specific requirements of each of the counties must be taken into consideration in modernizing and extending the system so that it will be a well-connected network of roads meeting the determined needs and traffic conditions of the various sections.

Such a program, of course, is one that requires thoughtful study, and presents its difficulties. Whereas in Europe many countries are building super-highways in anticipation of the growth in popularity and wider use of the automobile, here in America the automobile already is a dominant factor and automotive traffic has jumped ahead of our road building program.

Today we face the double problem of alleviating traffic congestion and building roads to meet the requirements of present-day highway necessities, and at the same time planning a broad-gauged road building program that will be commensurate with the anticipated traffic conditions of the future.

XVII. NEW FEATURES IN ROAD DESIGN

H. E. Surman*

The primary object of establishing design policies is to permit the construction of the safest possible highways within reasonable economic limits. Therefore, it is necessary in the consideration of such policies to give first thought to matters of safety. In the construction of State highways in the earlier days of the Bond Issue System little or no thought was given to the matter of safety as we now think of the problem. Low speed limit laws of the past are responsible for the low design standards used at that time. These standards were determined on a rather arbitrary basis, presumably based upon speed limits then existing, but providing no factor of safety to take care of future traffic speeds. Since the construction of these earlier highways at no time until recently have design policies kept sufficiently abreast of car speeds. This clearly indicates the necessity for introducing a factor of safety in our policies of design rather than being content to design only for present car speeds. Of course, it is much easier to look back and see the mistakes that have been made than to properly forecast future requirements, but our past experience should enable us to make much more accurate assumptions as to future needs.

The problem in design involves not only the construction of safe highways but also the factors of speed, weight, size, and number of vehicles. In order to adequately solve the design problem, we must know the dimensions, such as length, width and height, of the maximum vehicle which is to be permitted upon the highways. We must know the maximum gross weight, as well as the maximum axle or wheel load, and we must also know the maximum speed at which traffic will be permitted to travel upon the highway when completed. We must know, further, how many vehicles per day are going to use the highway under consideration, and the maximum number per hour. Of these factors, all are fixed by statute with the exception of maximum height of vehicle, maximum speed of vehicle, and amount of traffic per day. The question of height of vehicle can be dismissed, because this has been controlled through national policy, as well as by the policies in surrounding states, and also by the construction of several hundred subways under railroads and truss bridges over streams, all with fixed clearances. The question of amount of traffic is one that can be determined with reasonable accuracy from a study

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of population and traffic counts on completed roads where conditions are the same. There remains then the question of the speed of traffic which must be assumed by the engineer before attacking the problem.

In 1933 and 1934 manufacturers of automobiles made a drastic change in the design of the car by stepping up the speed, particularly with reference to the smaller model cars. When this change was made it immediately caused the obsolescence of most of the design policies with reference to the construction of highways in use at that time. This has since resulted in a material increase in the number of annual deaths upon our highways that are chargeable to design. We all know that car speeds will be still further increased in the future. It is therefore essential that design policies take this into account by adopting such policies as will forecast future speeds within reasonable limitations. This is the only way in which we can continue to build highways that will serve throughout their normal life without acquiring an unsatisfactory accident record chargeable to design.

With this in mind, the Division of Highways last fall put into effect some material changes with reference to several of the policies of design. The most important fundamental change is that policies will be determined from a definitely assumed design speed. For high-type pavement construction the design speeds will be 100, 80, and 65 miles per hour. Those designed for 100 miles per hour will be the dual-lane pavements with center parkway. The 80-mile-per-hour pavements will be those designed for two and three traffic lanes in level or rolling topography, and the 65-mile-per-hour speed will apply to pavements in hilly topography where economy or construction dictates the necessity for lower speed. For secondary roads the design speeds will be 65 and 50 miles per hour, the higher limit being used in level or rolling topography, and where traffic is sufficiently heavy to require some type of dustless surface. The 50-mile-per-hour speed will apply in the hilly sections of the State, where economy of construction must be considered, and to the lower type of traffic-bound surfaces in level or rolling sections. It is assumed, of course, that the design policies in all cases will be governed by the amount of traffic to be expected after the improvement is completed, and not by the fact that it is a Federal Aid, a State, or a County road. Particular attention is called to the fact that the speeds just mentioned are *design* speeds intended to provide a reasonable factor of safety.

With this fundamental change in the basis of establishing design policies, it is evident that a number of policies must be changed in order to comply with this requirement. This materially affects the

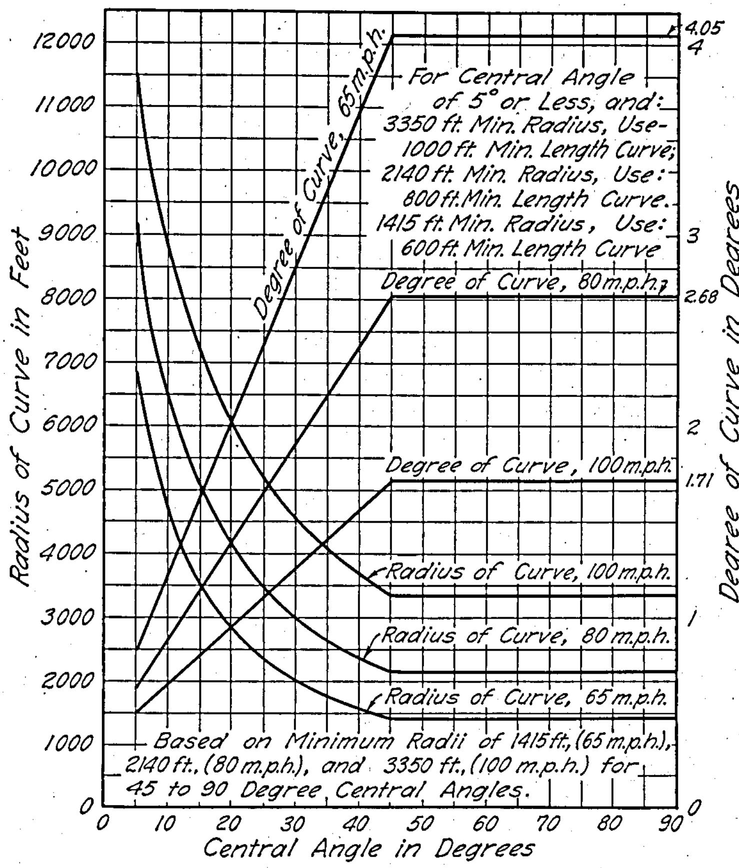

FIG. 1. RECOMMENDED RADIUS AND DEGREE OF CURVE FOR VARIOUS CENTRAL ANGLES AND SPEEDS

policies with reference to alignment, super-elevation, and sight distance. The revised policies for alignment and super-elevation are indicated in the tables and figures presented herewith.

It is noted from the chart showing recommended radius of curve that the minimum radius of curve for the 100-mile-per-hour design speed is 3350 feet, for the 80-mile speed, 2140 feet, for the 65-mile speed, 1415 feet, and for the 50-mile speed, 670 feet. These minimum radii apply to central angles of from 45 to 90 degrees. For smaller central angles the minimum radius of curve is increased as shown on the chart. This may seem like a radical change from our previous practice, but it shows how out of date our old policies were when ap-

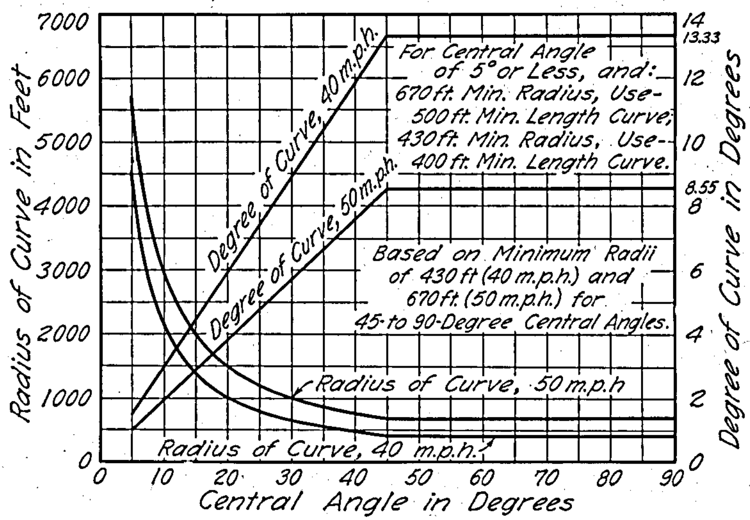

FIG. 2. RECOMMENDED RADIUS AND DEGREE OF CURVE FOR VARIOUS CENTRAL ANGLES AND SPEEDS

plying the test of design speed. These revised policies with reference to alignment will result in straighter and shorter highways which will therefore actually cost less than roads built under the alignment policies that prevailed prior to last fall.

The formula for computing super-elevation and radius of curvature in use in practically all of the states for many years has not taken into account the friction between the pavement and the wheels of the vehicle. As a result, we have generally used a value of S, speed of the vehicle, much below that actually used in negotiating a curve. In order that super-elevation may be properly computed, using the actual design speed for the value of S, we have revised the formula to take into account the friction. The revised formula is $E = \frac{0.067S^2}{R} - F$ as explained by the chart. According to experiments that have been made, there is indicated a value of F of 9.1 for speeds above 60 miles per hour and a value of approximately 9.15 for speeds under 60 miles per hour. In the formula shown on the attached chart, we have used these values, except that the value of F is decreased on a sliding scale for the longer radius curves because it was felt that a uniform value of friction used throughout would not give quite enough super-elevation in those cases. The maximum super-elevation has been changed to 0.1 of a foot per foot of width.

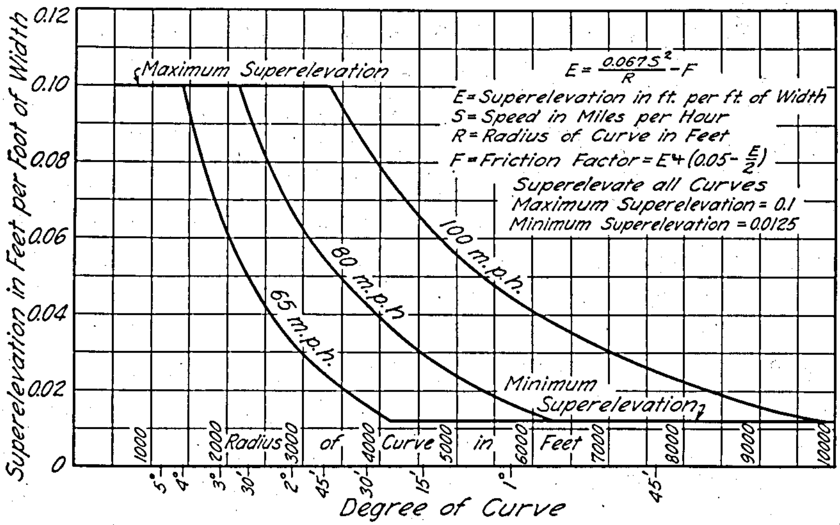

FIG. 3. SUPERELEVATION FOR VARIOUS DEGREES OF CURVE AND SPEEDS

The former policy was to super-elevate 1 inch per foot of width. The new policy therefore amounts to increasing the maximum super-elevation one-fifth inch per foot. All curves are super-elevated in accordance with the policy which has been in effect during the last four or five years, the minimum super-elevation being one-eighth inch per foot. The increase in the maximum super-elevation permits the use of a shorter radius of curvature when designing for a given speed. It is the intention, however, that longer curves than the minimum should be used wherever conditions permit in order to keep the amount of super-elevation below the maximum. There should be a very good reason for reducing the amount of super-elevation as computed from the foregoing formula, as this will reduce the safe speed of the curve very materially, with the result that it will become a point of potential hazard.

After the degree and radius of curve has been determined, it is necessary to compute the length of easement ahead of the P.C. or back of the P.T. in which the super-elevation should be developed. This is computed from the formula $L = \frac{1.58S^3}{R}$ where L equals the distance in feet from P.C. or P.T., S the speed in miles per hour, and R the radius of curve in feet. On this basis the length of easement for the minimum curve based on a 100-mile-per-hour speed is about 475 feet,

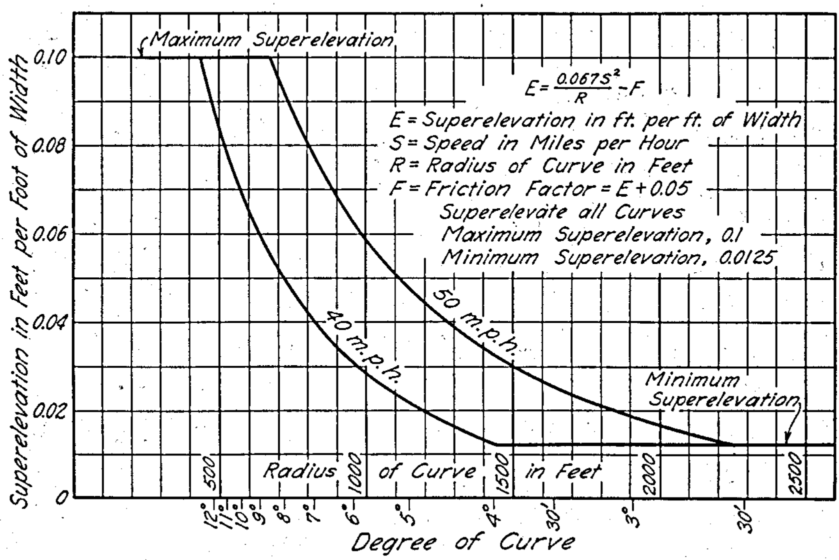

FIG. 4. SUPERELEVATION FOR VARIOUS DEGREES OF CURVE AND SPEEDS

for the 80-mile-per-hour speed, 380 feet, and for the 65- and 50-mile-per-hour speeds, approximately 300 feet. For longer radii the length of easement is decreased, and we have set minimum lengths of 25 feet for 20-foot pavements and 50 feet for 40-foot pavements. These easements are considerably longer than those used formerly, but are very essential when designing for higher vehicle speeds.

There has been considerable difference of opinion in regard to the length of sight distance that should be considered standard for the different classifications of highways. Some have recently suggested a safe passing sight distance. Such a policy would require sight distances of from 2400 feet to more than 5000 feet, depending upon the assumptions made in regard to the speeds of the various vehicles involved in a passing operation and the number of vehicles that are to be overtaken. It is obvious that even in gently rolling topography with maximum grades of only 3 or 4 per cent, such a policy would be very expensive. It would be far cheaper to use a dual-lane type of highway in gently rolling to hilly topography designed on the basis of a safe stopping sight distance than to use a two-traffic-lane design on the basis of a safe passing sight distance. Traffic is pretty well accustomed to the no-passing rule when approaching the upper end of a vertical curve. Too great a sight distance would encourage passing on vertical curves, and since it is very difficult to gauge the speed of oncoming

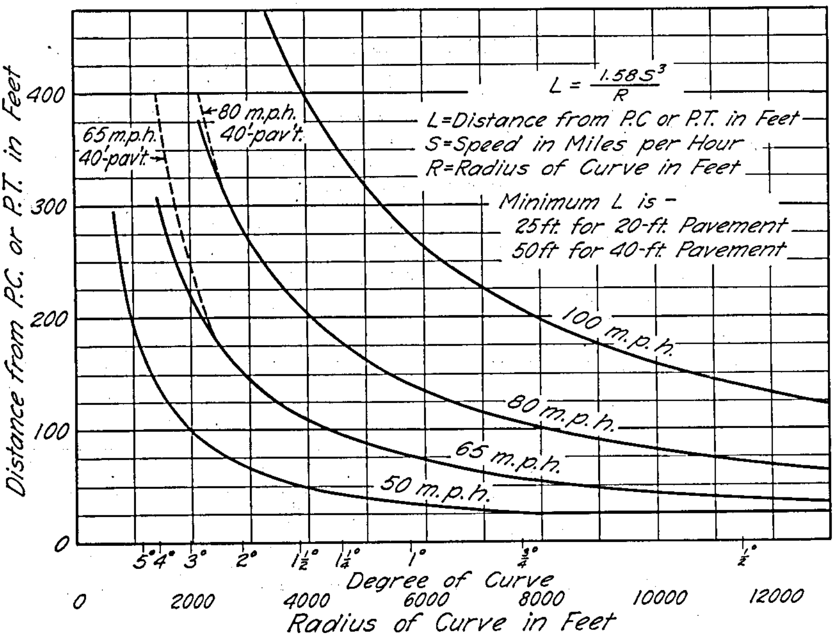

FIG. 5. DISTANCE AHEAD OF P.C. OR BACK OF P.T. AT WHICH SUPERELEVATION STARTS FOR VARIOUS DEGREES OF CURVE AND SPEEDS

traffic, especially under certain weather conditions, this might materially increase the number of accidents. With these points in mind, the Division of Highways has decided upon the following sight distances: For the 100-mile-per-hour speed, 1000 feet for 20- and 40-foot pavements, 1500 feet for 30-foot pavements, and 800 feet for dual-lane pavements; for the 80-mile-per-hour speed, 800 feet for 20- and 40-foot pavements, and 1000 feet for 30-foot pavements; for the 65-mile-per-hour speed, 600 feet for 20- and 40-foot pavements, 700 feet for 30-foot pavements, and 400 feet for dual-lane pavements; and for the 50-mile-per-hour speed, 400 feet for two-traffic-lane pavements. It should be remembered that these are minimum requirements, and while these will generally prevail with reference to steeper grades, we should make every effort to obtain longer sight distances where flatter grades are used, but with reasonable economy of construction.

It will be the policy of the Division of Highways to give more consideration to the construction of dual-lane highways where there is sufficient traffic to warrant such construction. In order to justify the design for four traffic lanes from an economy standpoint, there should

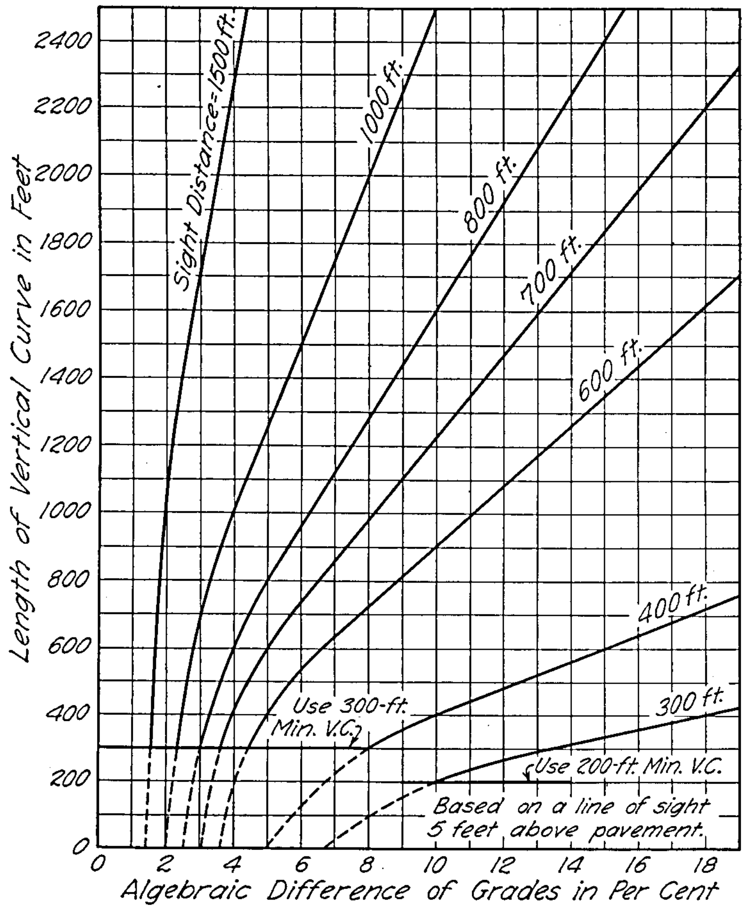

FIG. 6. LENGTHS OF VERTICAL CURVES REQUIRED TO OBTAIN VARIOUS SIGHT DISTANCES

Based on line of sight 5 feet above pavement

be an average week-day traffic of at least 3500 vehicles, with a daily week-end traffic of approximately 5500 vehicles. If this amount of traffic does not exist at present, but, based on reasonable assumptions, it can be forecast within the life of the pavement, then sufficient right of way should be secured to construct a four-traffic-lane pavement, but constructing by stage method an initial two-traffic-lane pavement which will fit into the ultimate improvement of the dual-lane design. The important details of design which should be embodied in dual-lane highway construction are 30-foot width of parkway, 22-foot width for each dual pavement, 10-foot width of shoulders, shallow side ditches, cross-overs at intersecting roads, entrances averaging not less than one-half mile apart, and provision for service drives where necessary. Of course, only a limited mileage of dual-lane highways can be considered even in our State because most roads do not have sufficient traffic to justify the extra cost of construction. Most of them will be located near the larger cities with only a very limited mileage scattered throughout the balance of the system. The dual type design has been used successfully for a number of years, and we should give it a more prominent place in our design studies than we have in the past. In the case of existing 40-foot pavements, some thought will be given to dividing the traffic by the construction of a center curb. However, before we go very far with this idea, we intend to do some experimenting to determine its value in reducing accidents.

It will be the policy of the Division to construct 22-foot width pavements in those cases where there is an existing traffic of 1500 vehicles per day, or where such an amount of traffic can be forecast within a reasonable time. This policy will apply mainly to the modernization of the existing system, but of course will apply also to new routes where they are of sufficient importance. It is felt that, with the continual increase in the speed of the vehicle, this change in policy is important in promoting safety.

The crown will be removed from the pavement for all curves of one degree and over for the 100-mile-per-hour speed, for all curves of one and one-half degrees and over for the 80-mile-per-hour speed, and for all curves of two and one-fourth degrees and over for the 65-mile-per-hour speed. For secondary roads the crown should be eliminated for the 65-mile-per-hour speed, and for all curves of five and one-half degrees and over for the 50-mile-per-hour speed. This policy should encourage drivers to keep in their proper lane in "rounding" curves.

It will be standard policy to construct as a part of the initial improvement stone or gravel approaches to mail boxes and at intersecting roads. This policy should of course apply to secondary roads as well as Federal Aid and State Highways.

Attention is called to the fact that we are still constructing too much guard fence. Now that we are building roadways with flat slopes, a large percentage of guard fence can be left off the plans. It is cheaper to flatten the slopes of hills to 3 to 1 up to 12 feet in height than to construct guard fences, and this policy will prevail in preparing plans in the future. Where there is any doubt in regard to the need for guard fence on tangents, a large saving may be effected by

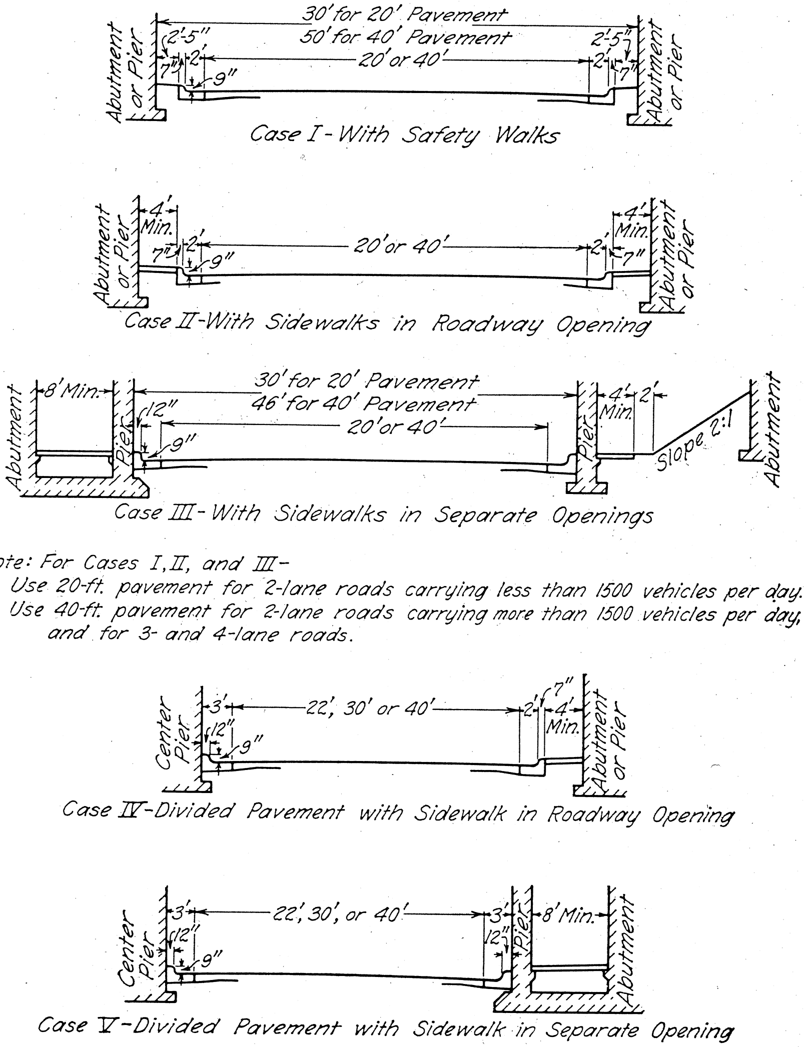

FIG. 7. MINIMUM HORIZONTAL CLEARANCES FOR SUBWAYS

placing posts, painted white, at intervals of 25 to 50 feet. This will often give sufficient psychological protection to avoid the necessity for building a complete fence.

A recent revision has been made with reference to the policy of bridge roadways, the principal change involving the addition of two safety walks, each having a width of 2 feet for all bridges on the primary road system. The need for safety walks on bridges for secondary roads is one that should be considered, and is left to the discretion of the county superintendent of highways. Of course, all bridges near cities and villages should provide for sidewalks. As a general rule, the clear roadway width, exclusive of the width of safety walks or sidewalks, will be 4 feet wider than the wearing surface approaching the bridge structure. Since bridges will serve many years longer than the pavement, it is necessary to make a longer range forecast of future traffic requirements. Therefore, we must either anticipate the need for supplying additional traffic lanes at some future time, or design the structure so that it can be widened without destroying the initial investment. This is a problem which, of course, pertains only to the more heavily travelled highways.

With reference to railroad grade separations, policies applying to overhead structures will be the same as applied to bridges over streams. Formerly we permitted a shorter sight distance in the case of railroad overhead projects. This practice will be discontinued and the standard sight distances will apply unless in specific cases an exception is deemed necessary, but there should be a good reason to support the exception. There are so many varied conditions involving roadway policies with reference to subways that it is necessary to demonstrate the present policy by enclosing sketches exemplifying different situations. As a general rule, center piers should not be permitted except in dual-lane highway construction. All subways, as well as overheads, will include either two sidewalks or two safety walks. For reasons of safety, as well as good appearance, single sidewalks or safety walks should not be considered. Since a railroad subway, like a bridge structure, is much more permanent than a highway pavement, it is necessary that we be rather liberal in making assumptions for the need of future traffic lanes.

The foregoing covers the more important changes adopted with reference to design policies during the past year, and is not intended to be a complete résumé of all policies. A complete outline of design policies is herewith presented in Figs. 1 to 7, and additional copies are available to the county superintendents of highways and others who may have use for them.

Design Policies for Rural Highways

	Primary Roads*	Secondary Roads*	Local Roads*
Design speed	100, 80 or 65 m.p.h.	65 or 50 m.p.h.	40 m.p.h.
Type of surface	Pavement	All-weather surface (dustless if possible)	Graded or oiled
Width of surface	20 ft., 22 ft., 30 ft., 40 ft., 44 ft.	18 ft., 20 ft.	
Shoulders	10 ft.	6 ft. to 8 ft.	Minimum shoulder to shoulder = 24 ft. 1½:1
Earth slopes	3:1 minimum for cuts up to 5 ft. 2:1 minimum for cuts over 5 ft. 3:1 min. for fills up to 12 ft. (no guard rail) 1½:1 min. for fills over 12 ft. (use guard rail) When guard rail is required slopes may be 1½:1	2:1 minimum for cuts up to 5 ft. 1½:1 minimum for cuts over 5 ft. 3:1 min. for fills up to 12 ft. (no guard rail) 1½:1 min. for fills over 12 ft. (use guard rail) When guard rail is required slopes may be 1½:1	
Right of way (minimum)	100 ft.	80 ft.	60 ft.
Alignment	Straight as feasible Eliminate small deflection angles; when necessary place at summits.	Straight as feasible	Straight as feasible
Horizontal curves (minimum)	3350 ft. for 100 m.p.h. 2140 ft. for 80 m.p.h. 1415 ft. for 65 m.p.h. For Central Angles of 45° to 90°. See chart for other angles.	1415 ft. for 65 m.p.h. 670 ft. for 50 m.p.h. For Central Angles of 45° to 90°. See chart for other angles.	430 ft. For Central Angles of 45° to 90°. See chart for other angles.
Super-elevation	From Super-elevation Chart	From Super-elevation Chart	From Super-elevation Chart
Super-elevation starts ahead of P.C. or back of P.T.	From Distance Chart	From Distance Chart	
Removal of crown	100 m.p.h.—curves 1° and over 80 m.p.h.—curves 1½° and over 65 m.p.h.—curves 2¼° and over	65 m.p.h.—curves 2¼° and over 50 m.p.h.—curves 5½° and over	
Sight distance (minimum)	100 m.p.h. / 80 m.p.h. / 65 m.p.h. 20, 22, and 40 ft. pavt.: 1000 / 800 / 600 30 ft. pavement: 1500 / 1000 / 700 44 ft. divided pavt.: 800 / 600 / 400	65 m.p.h.—700 ft. 50 m.p.h.—400 ft.	300 ft.
Grades (maximum)	100 m.p.h.—4 per cent 80 m.p.h.—5 per cent 65 m.p.h.—7 per cent	65 m.p.h.—7 per cent 50 m.p.h.—9 per cent	10 per cent

*Primary roads shall be defined as roads that will carry more than five hundred vehicles per day after the road is improved.
Secondary roads shall be defined as roads that will carry between one hundred and five hundred vehicles per day after the road is improved.
Local roads shall be defined as roads that will carry less than one hundred vehicles per day after the road is improved. It should be borne in mind that the above policies are the lowest which should be permitted.
Higher standards should be used whenever feasible.

DESIGN POLICIES FOR CITY STREETS

	Primary Streets*	Secondary Streets*
Type of surface	Pavement	All-weather surface (dustless if feasible)
Width of pavement, each traffic lane	10 ft.	10 ft. preferred—9 ft. minimum
Width of pavement, each parallel parking lane	8 ft. preferred—7 ft. minimum	8 ft. preferred—7 ft. minimum
Width of pavement, single car track	10 ft. preferred—8 ft. minimum	8 ft.
Width of pavement, double car track	20 ft. preferred—18 ft. minimum	18 ft.
Alignment, horizontal curves, sight distance	As close to rural policy as feasible; local conditions will govern	As close to rural policy as feasible; local conditions will govern
Grades	5 per cent if feasible. Avoid small grade changes. Use 100 ft. minimum vertical curve when necessary.	7 per cent if feasible.

*Primary streets shall be defined as streets that will carry more than five hundred vehicles per day after the street is improved.
Secondary streets shall be defined as streets that will carry less than five hundred vehicles per day after the street is improved.

Minimum Roadway Widths for Bridges

Primary Roads:

Length of bridge up to and including 50 ft., shoulder to shoulder; over 50 ft., total width of traffic lanes plus 4 ft. For 2-lane roads having more than 1500 vehicles per day, use 11 ft. traffic lanes; for other 2-lane roads, and for all 3- and 4-lane roads, use 10-ft traffic lanes.

Secondary Roads:

Length of bridge up to and including 30 ft., shoulder to shoulder; length of bridge over 30 ft., and up to and including 50 ft., 24 ft.; length of bridge over 50 ft., 22 ft.

Local Roads:

Length of bridge up to and including 10 ft., shoulder to shoulder; length of bridge over 10 ft., and up to and including 50 ft., 22 ft.; length of bridge over 50 ft., 20 ft.

Primary roads shall be defined as all roads that will carry more than five hundred vehicles per day after being improved.

Secondary roads shall be defined as those roads carrying between one hundred and five hundred vehicles per day after being improved.

Local roads shall be defined as roads that will carry less than one hundred vehicles per day after being improved.

It shall be borne in mind that the above roadway widths are minimum widths. All structures shall be designed to anticipate future traffic requirements; that is, for a period of at least twenty years.

Bridges on routes that will be widened to four traffic lanes or more within twenty years shall be built now to provide for the anticipated number of traffic lanes. Culverts on such highways shall be designed for the number of traffic lanes required within twenty years plus twenty feet, so as to provide for two ten-foot shoulders in addition to the space required for traffic.

Sidewalks, where required, shall be in addition to above minimum widths. All structures in or near cities and villages shall provide for sidewalks. For structures on primary roads, where sidewalks are not needed, 2 ft. safety walks shall be provided; the need for safety walks on secondary roads shall also be considered. When curbs are used on pavement adjacent to bridge, the face of curbs on bridge and pavement shall be in line. Height of curb on bridge, with or without sidewalk, shall be 8 inches.

XVIII. STREET DESIGN

E. K. McDonald*

This is not a technical paper. I will attempt only to give you as clearly and briefly as possible my opinions on the subject, and also some impressions received during the last several years while connected with the Engineering Department of the City of Decatur. The statements made are meant to apply to the average city having a population of 75 000 or less, where the problems are relatively simple as compared with those of larger cities. They will apply to Decatur more particularly, since that is the city with which I am the most familiar.

I have selected four separate points in the design of city streets each of which will be discussed generally and not in detail. The first of these points is widths of right-of-way; the second, sidewalks; the third, storm sewers and inlets; and the fourth, pavements.

(1) *Widths of Right-of-Way.*—The present City Engineer has very little control over width of right-of-way, or street width. This means almost without exception that street widths as established must be so used, and advantage taken of every available foot. Where possible, it is often better to transfer a portion of the traffic from a narrow street to one where the right-of-way is wider, rather than try to purchase or condemn private property. When a strip of ground 10 or 20 feet in width along either side of a street has to be purchased or condemned, it usually costs a lot of money. I think right here is the time and place to make a point which, in my opinion, applies to both present and proposed widths of right-of-way: Since pavement width depends entirely upon street width; since the amount of traffic any pavement can adequately and safely handle depends entirely upon its width; since street width changes are generally very expensive; then why not, at least temporarily, let traffic divide itself between two or possibly three streets? This makes the problem one of pavement widening only; and also has the added advantage of dividing the cost of public improvements between more people, with a resulting lower cost to each person where special assessment or special tax proceedings are being used.

One alternative to letting the traffic divide itself between streets is to provide for future widening by the passing of ordinances requiring all new buildings to be set back a uniform distance from the present street line. This idea is good, especially for those larger cities that

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are growing rapidly, and where many new buildings are being erected along streets that are certain to need widening. But who can be certain in the smaller cities like Decatur, just what streets will need widening 10, 20 or 50 years from now? A shopping district might change its location, a popular hamburger stand decide some other place would provide more parking space. There is no end to the possibilities. To consider it from a cost angle, I believe it is possible to widen the pavements on two or three streets for a lot less money than would be required to purchase new right-of-way to make it possible to widen the pavement on one street.

In Decatur practically all streets in the loop or business district are 80 feet in width, and in the residential and industrial districts 60 feet in width. While I do not mean to imply that this is an ideal situation, it works surprisingly well, especially so since very recently all street car lines have been abandoned and light, fast moving buses substituted. This tends to smooth out traffic and allow it to space itself more uniformly at intersections.

As you well know, a street car parked in the center of the street unloading or taking on passengers when the light is green, will often times hold up an entire line of cars. This is not true with buses. They, of course, are required to pull over near the curb when loading or unloading which allows plenty of space for moving traffic.

I believe now is the proper time to mention public alleys, and try to show why a 20-foot width alley in the business district is of real advantage when considering street widths. For example, a truck double-parked on the street fronting a place of business while unloading one or two small boxes can block very effectively one traffic lane for a distance of one or two hundred feet. This narrows the effective pavement width approximately eight feet. An alley 20 feet in width, with the proper ordinances, and their enforcement, requiring truck drivers to use alleys when unloading, will assure the use of the full pavement width for either curb parking or moving traffic. Many people think that alleys in the business district are merely catch-alls where you find rubbish swept from the stores, and blown from the streets. This is undoubtedly true in a lot of cases, but I think the advantage gained by keeping trucks off the streets, when double-parked for loading or unloading, more than offsets the cases where a dirty alley is found.

Alleys in the residential districts are, in my opinion, not needed. They do serve as a catch-all for ashes, garbage, tin cans and anything else not wanted in house or yard. They are of no special use, since the majority of houses have private driveways to their garages entering from the streets. Why not vacate all present residential alleys and lengthen the lots by several feet, retaining easements for public and private utilities where necessary? With alleys vacated a roadway would not have to be maintained, this allowing plenty of space for unsightly pole lines now located on streets.

(2) *Sidewalks.*—In street design, one of the most important points for consideration is sidewalks. Where is the sidewalk located with reference to property lines? What is the grade and elevation as compared with surrounding land, houses, and pavements? Does it slope towards the center of the street, as it should, or in just the opposite direction, as a great many do? Some people consider me a fanatic on the subject of sidewalk design, and on first thought it seems to merit little consideration. But I still insist that any reasonable amount of time taken by an engineer to determine the exact line and grade of a sidewalk is well spent.

A steep private driveway may be eliminated. Property owners will be able to set their newly-built houses at correct elevations so that proper yard and basement drainage results. All public and private utilities know where to place their service pipes and wires. In fact, it is my opinion that a sidewalk set in proper alignment and grade will, more than any other one thing, assure correct street design.

In the business district, and all other places where a large amount of pedestrian traffic makes it impossible to keep a decent looking grass plot, the entire space from the property line to the curb line should be sidewalk.

In residential districts where the sidewalk is not used continually, and where the entire width of right-of-way does not have to be used to handle automobile traffic adequately, it is a good plan to set the walk one foot from the property line. The advantage in having this one foot of street between the sidewalk and property line is that the city can control what is placed there. It can insist, for instance, that house walks which intersect and are higher than the city walk, have the riser of the step or steps placed on private property. This will eliminate a possible stumbling block at the inside of the city sidewalk. Some people also like to have a low retaining wall around their yard. The city can insist that this wall be built on private property, and the space between the wall and the walk be filled with sidewalk. This has the advantage of leaving a full five foot width which can be used by pedestrians without causing them to bump into or brush against the retaining wall.

I think a practical width for a permanent sidewalk in the residential district is five feet. This allows two people to walk abreast with plenty of room. Any width narrower than this, unless of a temporary nature, is impractical, and the additional expense of the five-foot walk is negligible. This width, except on streets which have an unusual amount of automobile traffic, and where a very wide pavement is required, allows plenty of room for a grass and tree plot between the walk and the curb.

(3) *Storm Water Sewers and Inlets.*—There are just one or two things about these, which, in my opinion, are rather important. The location of the inlets should be given some consideration. For instance, in many cities, Decatur included, inlets have been placed directly in the sidewalk line. In this case, people walking, during or after a rain, either have to wade through the water, jump over it, or possibly go around over a muddy grass plot.

Suppose also that this badly-located inlet is designed with a removable top for clean-out purposes, and that this top is, through age, or, from being carelessly replaced, a little loose and liable to tip, if someone should step on it at a certain spot. The condition is now dangerous. Decatur has paid several clothing and doctor bills in the last few years for people who have fallen into storm water inlets.

There is little that can be said about the size of either inlets or sewers, except that they should both be large enough to carry off, quickly, any normally large rain.

Inlets whether attached to a sewer carrying only storm water, or to a combined system carrying both storm and sanitary sewage, should, in my opinion, be trapped. This trap, if properly made, will eliminate most of the sewer odors sometimes noticeable near inlets. The reason for trapping an inlet attached to a sewer carrying only storm water is that somewhere along the line of the sewer a property owner usually manages, either through intent or carelessness, to attach a basement drain, or possibly even a toilet.

Inlets should either have a removable top setting back of the curb, or a removable street grate setting in front of the curb. This makes it possible to clean them, and this cleaning should be done at least twice each year. Where the location of an inlet is such that people are required to walk over it, or possibly stand near it, I much prefer the street grate, as this type reduces the possibility of an accident to a minimum. In places where there is no possibility, or at least very little chance, of anybody standing near, I much prefer the type having a removable top. Such inlets are much easier and cheaper to clean.

I will not attempt to describe an ideal location for either storm water sewers or inlets. Usually each of the low points where both have to be located presents a different problem which must be solved individually.

(4) *Pavements.*—Pavements in the business district, like streets over the entire city, can very rarely be widened. This means that if traffic is to be accommodated on streets having narrow pavements other solutions must be found.

In some places these narrow pavements which it is impossible to widen through lack of money or inadequate street width can be restricted to one-way traffic. This in effect, doubles the pavement width. Another way, but in my opinion not always satisfactory, is to stop parking on one or both sides. This often creates a hardship for abutting commercial property, and a nuisance for the Police Department. However, it should be done in the interest of safety, where a bottle-neck to traffic occurs. The manner in which cars are parked is important to pavement widths. A thorough study of parking is well worth while and the effective width of present pavements can often be increased at practically no cost. The narrowest pavement in the Decatur business district is 40 feet, the widest is 52 feet. As now used, the 52-foot width, divided into four nine-and-one-half-foot traffic lanes and two seven-foot parking lanes, is satisfactory. The pavements less than 52 feet wide are crowded. A satisfactory width for pavements in a purely residential district is thirty feet. This allows sufficient space for both traffic and parking, and does not load on the property owner the heavy expense of a wider pavement which will be little used. To provide for two seven-foot parking lanes is not necessary, in my opinion, as most property owners and their friends prefer to park their cars in their own private drives, thus eliminating all chance of a sideswipe or collision. This also will save the car battery at night.

Arterial residential streets and those carrying a State or Federal Route, of course, should have a wider pavement, the width to depend entirely upon the amount of traffic and the amount of parking. In all except extreme cases a thirty-six foot pavement will be satisfactory, giving two ten-foot traffic lanes and two eight-foot parking lanes.

I think the marking of traffic and parking lanes on city pavements with paint or asphalt is of distinct advantage to traffic control, and thus to pavement width.

Within the last three years private driveway approaches have become a very important point in street design. All cars are being built with less road clearance. A large percentage of the cars have bumper guards projecting down from three to five inches lower than ever before. This means that drive approaches which heretofore have been satisfactory are now too steep; some part of the car drags, possibly a front or rear bumper guard, a running board or a transmission. Occasionally this dragging can be eliminated by backing into the driveway; more often, however, it means the lowering of a sidewalk. If the walk is high above the gutter for some distance, and affects several drives, the ideal thing is for all property owners to get together, lower the high walk, construct new drives, and grade their yards to fit.

If only one or two drives are affected, and the distance the walk must be lowered does not exceed six inches, a satisfactory solution is the removing and replacing at the required grade of about twenty lineal feet of walk for each ten-foot drive. This required grade can be obtained by giving the walk a fall of three-fourths inch to the foot towards the curb, instead of one-fourth inch, which is usually standard. A slope of three-fourths inch to the foot, for a sidewalk, is maximum for safety, in my opinion. Anything steeper is dangerous for pedestrians especially in snowy or icy weather. If an additional two or three inches more is needed then the entire walk can be lowered for the width of the drive and the sidewalk on either side warped to fit.

Experience has shown that where a sidewalk is five feet wide and the driveway from the walk toward the garage has just enough slope to the street for drainage, a gradient of not to exceed 14 per cent between the sidewalk and curb is the steepest possible. This applies only when the distance between the outside of the walk and the face of curb does not exceed four feet. Where the distance between the walk and curb is ten feet or more the gradient must be flattened to not more than eight per cent. The steeper gradient is possible with a narrow grass plot because the front wheels of a car start to drop immediately after passing the outside edge of the sidewalk, thus raising the rear bumper and allowing it to clear the pavement. In case of a wider grass plot the front wheels are rising continually and do not start to drop until after the bumper drags, thus requiring a flatter gradient.

In street design, it is impossible to overlook the subject of the salvage of existing pavements; a money saving is the result in a large number of cases. The questions to be answered when deciding between a resurfacing or a new job are: Are the line and grade correct, or nearly so? Should the pavement be widened? How may the drainage be adjusted to fit new grades if no widening is considered, and to fit new lines and grades if widening is considered? Will the present crown be satisfactory? Is the pavement, when used as a base, adequate? Naturally it is impossible for anyone to answer these questions except when applied to a particular street. Those of you who are familiar with resurfacing will perhaps wonder why the question of height of curb after resurfacing was not included with the others. This is because I don't think it important. If the grade of a street is correct, the top surface of a resurfacing material which raises the gutter 3 to 3½ inches will leave 2½ to 3 inches of a 6-inch curb showing. This height is sufficient in the majority of cases to keep surface water from overflowing the grass plot and depositing dirt and leaves. Raising the gutter will also in some cases eliminate a steep driveway without sidewalk adjustments.

After the question of line, grade, widening, drainage, crown, and base have been answered, the next thing to consider is the cost of each. If the cost estimate shows a decided difference in favor of the new job, then build a new pavement. There is no question in my mind but that certain refinements can be incorporated in new work that are impossible with a resurfacing job. However, if the cost is in favor of the resurfacing, then resurface. Remember that the questions of line, grade, etc., have already been answered, and that resurfacing was considered feasible before going to the trouble of making a cost estimate.

Decatur has over 200 000 square yards of resurfacing. I should say 95 per cent of this is entirely satisfactory to date, after having been in use over 12 years. A major portion of this yardage carries now and has carried the City's heaviest traffic for the entire 12-year period. Visual inspection will convince you that its condition at present is excellent, and that it should last for at least another 12 years.

To sum up the different points covered; When a narrow street with a narrow pavement is carrying too much traffic, make it convenient for one or possibly two others to carry a portion of this traffic and relieve the condition. Give a change of parking rules consideration. One-way traffic might help. Where alleys are available in the business district, make it necessary for trucks to use them when unloading. Why not vacate public alleys in the residential district? In establishing line and grade for new sidewalks see that it is correctly done. This will help eliminate future steep driveways, and assure correct surface and basement drainage for newly-built houses. When locating and choosing the type of storm-water inlets think about the convenience and safety of the pedestrian and the cost of cleaning. Investigate old pavements that need improving. This may show that resurfacing is feasible.

In all of these ways, and many others not mentioned, it is my definite opinion that a street design, which at present is not ideal, can in all cases be partially corrected, and in many cases be made to serve the public satisfactorily, without major changes in design and for a reasonable cost.

In conclusion, let me say that all the officials of the City of Decatur enjoy a trip to Paris or Springfield to see members of the State Highway Department. We like to visit with them and get their ideas and advice on various improvements. There are, of course, slight differences of opinion, but we have found that they are fair, and always willing to give and take when the same attitude is assumed by the City.

XIX. THE 1937 FLOODS IN SOUTHERN ILLINOIS

G. A. SOMERVILLE*

The year 1937 will go down in the history of the Ohio River Valley as the year of the greatest flood known to that area. No longer will the old river men be able to spin tales of the high water of 1913, and they will be forced to modernize their stories to coincide with the conditions of the present flood.

The crest of the 1937 flood at Cairo was approximately 4.8 ft. higher than that of the 1913 flood. The Cairo gauge reading of 1913 at the crest was 54.8 and the crest reading for 1937 was 59.62. However, during the major flood on the Mississippi River in 1927, the Cairo gauge reading was 56.4.

At Golconda, some seventy-five miles up the river from Cairo, the crest of the flood was approximately 6 ft. higher than the 1913 flood. Engineers from this district are now securing all possible data on high water elevations in the flooded area.

Cause of Flood.—Heavy rainfall in the Ohio River Valley, starting about January 13 and extending up the Valley until about January 25, was the prime cause of this great disaster. An area from north of Memphis to south of Louisville showed a 20-in. rainfall in 25 days, the rainfall gradually diminishing as it extended northeasterly from this point, until about a 4-in. rainfall was recorded in the vicinity of Pittsburgh.

Ice and snow in the Ohio River Valley added greatly to the run-off, and in Southern Illinois at the beginning of this downpour the ground had been covered with a sheet of ice; later, when the main flood reached this area, we were also handicapped by an 8-in. snowfall. Warnings from the U. S. Weather Bureau and the U. S. Engineer's Office in the upper reaches of the Ohio River Valley reported appalling gauge readings which were only too good evidence that the disastrous flood was on its way down the Valley.

Start of Flood in Southern Illinois.—The start of the flood in Southern Illinois was about January 13 and 14, with heavy rainfall and excessive headwater in the Saline River, Cache River, and Crab Orchard Creek. This headwater flooded Crab Orchard Fill on S. B. Route 13 east of Carbondale to a depth of about 23 in., washing away practically all the down-stream guard fence and shoulder and undermining the slab in some places almost to the centerline. On S. B.

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Route 143 north of Harrisburg, practically all of the fill was flooded by the Middle Fork of the Saline River, and a minor flood was caused in the northern section of Harrisburg. However, they were to experience a flood at Harrisburg that made this flood seem like a dry day in August. U. S. Route 45 south of Texas City was also flooded with headwater. This headwater rapidly receded, but in a few days the backwater from the Ohio River flooded S. B. Route 13 at Junction and east of Equality, and the creosoted block floor on the steel span over the North Fork of the Saline River at this point was loaded with wire mesh guard fence and sandbags to keep the floor intact. This backwater rapidly spread to U. S. Route 45 at Texas City and many other points on the Bond-Issue System, traffic being cut off at Shawneetown about January 22.

The Kentucky approach to the Paducah-Brookport Bridge was blocked by backwater on January 22, and the approach to this same Bridge on the Illinois side was blocked on January 23, the water rising at a very rapid rate over the entire area of Southern Illinois, along the Ohio River.

Illinois National Guard.—It was very evident that Southern Illinois was due for a very disastrous flood and Col. Robert Davis, Commanding the 130th Inf., was placed in charge of the flood situation in Southern Illinois, establishing his general headquarters at Eldorado. Several companies of the Illinois National Guardsmen were rushed to the scene, and these men did very effective work in policing these areas, and still are on duty during the rehabilitation period.

General Organization of District No. 9 for Flood Defense.—Telephone calls poured into the District Office so rapidly that it was necessary to establish a "dispatch desk" in the Maintenance Office, placing two engineers on 8-hour shifts for a 24-hour period, and they handled, in a very satisfactory manner, the calls for help that we received. In addition to the trucks in this district, about seventy large trucks were sent to our aid from various districts in the state, and the Day Labor organization in Springfield. With this large force of trucks, it was necessary to establish a truck register, handled by two of the engineers, and they assigned trucks to various details throughout the district. Contact men were stationed in Col. Davis' Office at Eldorado, the W.P.A. Office at Harrisburg, and the U.S. Army Engineer's Office at Cairo, to keep the work of our department coördinated with their organizations. Engineers were assigned to gauge stations along the Golconda Gap, and a detail of some twenty-eight engineers were eventually assigned to supplement the U.S. Army engineers at Cairo. Mr. C.

Fig. 1. Harrisburg, Illinois, Looking North on U.S. 45 Near North City Limits. Water Reached Level Indicated by Broken Line on February 3, 1937

A. Case, Assistant District Engineer, and myself acted as field observers, and attempted to bring back each night a picture of the flood to the men at the dispatcher's desk, so that they would be in a better position to coördinate the efforts of the Department.

Harrisburg.—In the early stages of the flood, it was very evident that motor transportation into Harrisburg would be cut off on the Bond-Issue Routes from the north, east, and south, and, on January 24, we stationed several engineers and rodmen in Harrisburg, whose duty was to keep traffic moving into Harrisburg on S. B. Route 13 from the west.

A fleet of twenty-five trucks and one of the State cranes were rushed to Harrisburg, and our first plan was to sandbag Route 13 at the west corporate limits, thinking the water would probably be about 3 ft. deep at this point. After one day's back-breaking work, this plan was abandoned, and the crew fell back to a point about a mile west, utilizing a Motor Fuel Tax road running south from Route 13 and raising the low spots by hauling mine refuse from nearby mines. No sooner was this job well underway, than the water cut them off west of this point, flooding most of the work they had done; and they were forced to establish a detour, leaving Route 13 about five miles west of Harrisburg, going south to Carrier Mills and thence northeast into Harrisburg on U. S. Route 45 to a point southwest of Harrisburg, and then into the higher ground in the south portion of that city. From that point it was necessary to take transportation into Harrisburg by boat, our force building a boat landing at the McKinley School, which was the south limit of the water gap. This crew also sandbagged a dairy in this vicinity and installed a pump, so that this firm could continue business and supply milk to the residents of Harrisburg during the flood. They also hauled thousands of milk-cans filled with water, loading them into barges and towing them to the center of the town. We also supplied a large generator for telephone and radio communications, and helped sandbag the shaft of the Peabody Coal Co. mine, by loaning them our crane. At the end of the first week, most of this organization was completely exhausted, and they were relieved by other engineers, who carried on the work at Harrisburg for the remainder of the flood.

Shawneetown.—The flood waters had completely isolated Shawneetown for several days and finally, on January 25, the back levee broke at a point a few hundred feet south of where Route 13 crosses this levee, and it was only a matter of a short time before the entire town was completely inundated, the water standing at about the level of the second floor of the buildings. The Illinois Naval Militia from Chicago established a water base at Equality and, along with the Conservation Department boats and one boat from the Illinois Highway Department, they did very effective work in removing refugees and carrying supplies to people isolated in the area directly west of Shawneetown. Our Department aided the Naval Militia in unloading their power cutters from flat cars at Equality. Without the aid of these units at this location, the people of Shawneetown, indeed, would have been in terrible circumstances.

U. S. Army Engineer's Water Base at Golconda.—While all this was going on at Harrisburg and Shawneetown, we received telegraphic instructions that the U. S. Army engineers were to establish a water base at Golconda to evacuate refugees from Paducah and points north of Golconda. The flood waters had covered only a small portion of the fill on S. B. Route 146 directly west of the town, and we first attempted to build sandbag ramps to act as unloading docks, but this was soon abandoned, as the water rose rapidly; and finally a temporary steamboat landing was constructed on the north side of our fill about a mile west of Golconda, the water eventually flooding this fill to a depth of about 3 feet. The U. S. Army engineers established their water base in the vicinity of Lusk Creek Bridge on Route 34, directly north of Golconda, and were prepared to evacuate the Paducah refugees by January 27, but the order of evacuation was changed, and the

Paducah refugees were taken to points southwest of that city. However, several hundred refugees were evacuated through Golconda from points up the river. It was necessary that a large gap be torn out of Route 34 to allow these boats to proceed west to the landing on Route 146. This gap was later roughly filled in by the U. S. engineers after the water receded, and this will be one of the many places that will be rebuilt later on.

Mounds and Mound City.—The flood waters rose so rapidly that it was almost impossible to keep up with the situation. A group of maintenance patrolmen were stationed at Cache River Bridge on U. S. Route 51 and were very effective in their efforts to remove drift from this bridge, the current in this river having reversed itself, flowing from east to west through the long trestle on Route 150, and thence into the Mississippi River. A detail of engineers were also in this vicinity, helping on bulkhead work at Mound City and on Route 37 north of that town, this portion of Route 37 being a part of the levee protection for Mounds. These engineers did excellent work, but it was of no avail, as Route 37 north of Mound City started flooding on January 24; and, when it was found that Mounds could not be saved, our engineers called for every available boat to be sent to that city, to rescue the people marooned in their homes. Our trucks hauled from fifteen to twenty row-boats from Carbondale and Anna, and these were manned by men supplied by the U. S. Engineer's Office, and excellent work was done in rescue work with these boats. It would be hard to describe the conditions at Mounds and Mound City at that time, unless one had actually viewed it with his own eyes.

After the Mounds area had flooded, the water broke over the fill at the National Cemetery, and orders were received from the U. S. Engineer's Office at Cairo to commence sandbagging U. S. Route 51, directly south of the Cache River at the outer levee.

On January 27, the west levee at Mound City that had been partly bulkheaded failed, and that city was soon inundated.

The crown elevation of the pavement on Route 37 north of Mound City is elevation 331.50, and this grade runs north from the Mound City levee for a distance of about two miles. The crown elevation of this pavement equals 60.6 on the Cairo gauge, and it was estimated that the water flooded this fill to a depth of about 2 feet, making the elevation of the water at its crest about 62.6 on the Cairo gauge. This is at a point only a few miles north of the outer Cairo levee, which, after the bulkhead work had been completed, was at elevation 62.0, so it is very evident that, if the area around Mounds and Mound City and the New Madrid Floodway of 131,000 acres had not been inundated, the story of Cairo would probably have been a different one.

At the crest of the flood Cairo was a small island several miles from the Kentucky and Missouri shores, with only Route 150 as its connection to the mainland of Illinois.

Golconda Gap.—About five miles south of Golconda on the Ohio River there is a low spot running entirely across the State from east to west that is claimed to have been the original channel of the Ohio River, the major part of this low area being the Cache River basin. This entire area rapidly flooded, with a strong current estimated at from ten to twelve miles per hour from east to west. This area was termed the Golconda Gap by the U. S. Engineers, and it flooded Route 145 south of Renshaw, U. S. Route 45 for several miles south of Vienna, Route 37 south of Cypress, and U. S. Route 51 south of Ullin, the water flowing southwesterly from this point past Tamms and through the 2900-ft. trestle on Route 150, and thence into the Mississippi River area.

The Army engineers asked that gauge stations be established at the points just mentioned and this was done, with an engineer and rodman at each location on twelve hour shifts. Gauges were read every hour, and reported to the Carbondale Office every six hours, and we, in turn, reported these readings to the U. S. Army Engineer's Office at Cairo. A patrol was also established on Route 150 between Olive Branch and Cache, to remove drift from the long trestle, and to keep a watchful eye on this long fill, as Route 150 was the only available means of transportation into Cairo at that time, every railroad line into Cairo having suffered many washouts or being completely inundated.

The Illinois Naval Militia established a base at Ullin and, with the help of the Conservation Department boats and several boats from Beardstown, manned by experienced river men, water service was established at Ullin on U. S. Route 51, at Cypress on Route 37, and at Renshaw on Route 145. The water gap on U. S. Route 45 south of Vienna was entirely too long and too badly blocked with drift to make it practical for water transportation. Refugees were transported to safety at all of these points, and supplies for Metropolis and the other towns south of this water gap were hauled in by boat and pontoons supplied by a pontoon company of the National Guard from Chicago. As the flood progressed, the District Planning Office platted the flooded areas on our district map, and copies of this map were distributed to National Guard officers, W.P.A. officials and officers of the Illinois

Naval Militia, and were very helpful to these officials, as a great many of them were entire strangers to this section of Illinois.

Cairo.—The U. S. Army engineers at Cairo had their hands full with the situation at that point, as well as points further down the river, and they asked that a detail of engineers from our office be sent to Cairo to supplement the work of their engineers. This detail consisted of two contact men in the U. S. Engineer's Office, the remainder of the detail doing supervisory patrol duty on the 3-ft. bulkheads that were being constructed on the inner levee around Cairo, and the 2-ft. bulkheads on the levee in the outer area. Thousands of men from W.P.A. forces, C.C.C. forces and individual citizens of Cairo were pressed into service to build these bulkheads, and our engineers were utilized to supervise this construction work, as well as the patrolling of the levee at night. In addition to these duties, we were forced to sandbag a long section of U. S. Route 51 at a point south of the intersection of Route 150 and U. S. Route 51, and installed two pumps to keep this length of pavement passable at all times. We also operated the large levee pump that removed the seep-water from the outer levee, but this levee pump had a hard time to keep ahead of the seep-water. However, at no time did we have more than 1 in. of seep-water over the pavement at this point.

Area Inundated in Southern Illinois.—Following is a table showing the mileage of roads, both primary and secondary, inundated in this area, and a table showing by counties the inundated areas in square miles:

The mileage of roads *under* water by counties by various classifications is as follows:

	Primary Roads		Secondary Roads	
	Miles F. A. System	Miles Non F. A.	Miles F. A. Routes	Miles Non F. A.
Alexander	1.0	0.0	11.0	59.0
Pulaski	13.0	0.0	3.0	100.0
Massac	14.0	0.5	0.0	93.0
Pope	1.0	5.5	0.0	75.0
Hardin	2.5	0.0	0.0	26.0
Gallatin	12.0	0.0	0.0	300.0
Saline	24.0	8.5	0.0	150.0
Johnson	1.0	0.0	0.0	20.0
Union	0.0	0.0	0.0	4.0
Hamilton	0.0	2.0	0.0	23.0
White	0.5	0.0	0.0	265.5
Crawford	0.0	0.0	3.0	25.0
Edwards	0.0	0.0	0.0	9.5
Lawrence	0.1	0.0	0.0	42.1
Wabash	0.5	0.0	0.0	37.0
Total	69.6	16.5	17.0	1229.1

AREA SQUARE MILES

County	Total	Inundated	% Inundated
Alexander	232	77	33
Gallatin	328	198	60
Hardin	178	22	12
Johnson	349	24	7
Massac	245	93	38
Pope	374	60	16
Pulaski	199	80	40
Saline	390	115	30
Union	410	2	0.4
Hamilton	427	65	15
White	509	199	39
Total	3641	935	

As the crest of the flood receded, it was necessary to barricade all of our routes that had been inundated until a thorough inspection of the slab, shoulders and bridges could be made, before throwing them open to traffic. The engineers in charge of the various areas had a difficult time with this procedure as the water receded so rapidly on some of the rather level areas that a route would clear before proper inspection could be made.

Damage to Roads and Bridges.—The damage was much less than originally contemplated. On the routes inundated by the Golconda Gap very little shoulder wash occurred. Apparently the extreme depth of the water on these routes accounted for the lack of wash on the shoulders. The greatest damage was on S. B. Route 37 north of Mound City. At this location the roadway embankment also acts as the east levee for Mounds, but as the Ohio River inundated this Route to a depth of about 2 feet, practically all of the down-stream shoulder and guard fence for a distance of 2 miles was completely washed away. The pavement was undercut for a distance of 2 feet to several feet back of the centerline of the pavement, and from 300 to 400 feet of the slab on the worst undercuts has fallen in. It is intended to shore up the undercut slab on this portion of Route 37 and backfill with compacted earth, remove the shoring, and then replace the shoulder and slope. A type of earth suitable for both road and levee construction may be obtained a few miles north of this location and will be brought in by trucks. No accurate estimate can be made until the water recedes, but there will probably be in the neighborhood of 60 000 cubic yards needed at this one place. In repairing the slides, the new cross section will probably show much flatter slopes than the original fill. On Route 34, both at Golconda and Elizabethtown, where presumably the fill has a high silt content, the slopes have

FIG. 2. LOOKING SOUTH TOWARD MOUND CITY ON ROUTE 37, SHOWING DAMAGE TO SLAB BY UNDERCUTTING

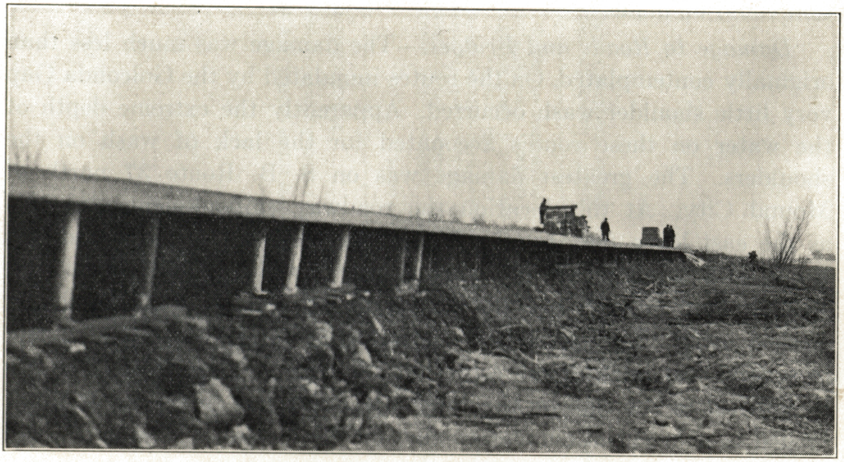

FIG. 3. LOOKING SOUTH TOWARD MOUND CITY ON ROUTE 37, SHOWING METHOD OF SHORING UNDERCUT SLAB TO PREVENT FURTHER FAILURE

sloughed very badly and considerable pavement may be lost at both locations.

The damage done to roads on the State system will amount to approximately \$200 000. A hurried estimate of damage to County and Township roads and bridges, both from headwater and floodwater, shows a figure of about \$325 000.

Rehabilitation in Flooded Areas.—The enormous task of rehabilitating the towns and villages in this section of Illinois has been assigned to the sanitary engineers of the Department of Public Health and they have made a complete inspection of water supply and sanitary conditions before allowing the inhabitants of the towns to return to their homes. Theirs is an exceedingly difficult job and they have handled it in an excellent manner. This district has supplied the sanitary engineers with trucks for a limited period of time, and have also supplied them with a great many 2-in. centrifugal pumps, which they used in pumping the basements of public buildings.

Already some of the people are returning to their homes, and things are gradually being restored to normal by the process of drying out what few household goods can be salvaged; but in the main they are in a pitiful condition, and it must take a great deal of courage for them to carry on. While they are attempting to re-establish their flooded homes, their ardent plea and prayer is "Old Man River, Stay Away from My Door."

XX. THE DISASTER RELIEF PLAN OF THE AMERICAN RED CROSS

S. F. WILSON*

You have been hearing about the Red Cross in the 1937 flood disaster—the name bobs up at all times in floods such as this, or other disasters. You have heard that C.C.C. companies and army detachments were sent from long distances to report to the Red Cross. You may have heard that approximately 500 coast guardsmen were sent from the Atlantic Coast, Gloucester, Massachusetts, and other distant points to the East St. Louis Red Cross to be later sent to the Red Cross at Cairo, Illinois, and it is possible that you may at times have wondered how the Red Cross rates such prestige. There are two answers to this. One is that the Red Cross, through a great number of years, has won the confidence of the American people, and there is no resentment when government forces are used under its supervision. The other answer is that the President of the American Red Cross is Franklin D. Roosevelt, so you can see that when the President of the American Red Cross, who is incidentally President of the United States, says that a coast guardsman of Gloucester, Massachusetts, should be sent to Cairo, Illinois, by way of East St. Louis, it is no sooner said than this coast guardsman is on the way. But do not get the impression that the Red Cross is a New Deal idea. The First Vice-President is Charles Evans Hughes, Chief Justice of the United States Supreme Court. That should make it constitutional, I suppose. The Second Vice-President is Herbert Hoover. It will not be necessary for me to recall to your mind that he is one of our leading engineers. The Treasurer of the American Red Cross is Wayne C. Taylor, Assistant Secretary of the United States Treasury. Anyone handling Red Cross funds might bear that point in mind.

In brief, the American Red Cross is a semi-governmental organization, chartered by Congress to furnish volunteer aid in time of war and to sufferers by disaster, famine, or epidemic disease during peace.

My connection with the American Red Cross came about in this way: In reading about various disasters throughout the country, especially the one at Murphysboro at which there was a large loss of life, and the one in St. Louis a few years ago where the loss of life was not so great, but where property damage was tremendous, I got to thinking, "Just what would a certain District Engineer of the Highway

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Department do if such a storm struck East St. Louis?". We would probably be cut off from telephone and telegraph communication, and it struck me that we could sit down and do nothing and be criticized, or make some effort to go out and do something and be criticized anyway, probably by our Springfield office. I knew practically nothing about the Red Cross, and, knowing they took a prominent part in all disasters, I decided to call on them just to find out what procedure they followed and how they operated. As soon as I started asking questions, they said, "You are just the man we are looking for." If you have ever shown any interest in any volunteer civic organization you know how easy it is to get a job. I was immediately put on their Transportation Committee. In about three months I was made a member of the Red Cross Council, and a year later, when I knew something about the Red Cross, I was put in as Chairman of the Major Disaster Relief Committee. You can see from this that my rise was meteoric, not to say phenomenal.

But the thing I wanted to bring before this meeting is that the American Red Cross has a plan for disaster relief and they welcome the formation of committees in all populous areas of the state to carry out this plan. In brief, a committee is formed to consider what should be done in case a disaster should strike its community. There is no particular set plan, of course, but the plan they recommend has a chairman and sub-committees. The chairman should be a sort of champion hog caller and calamity howler combined so that he can call attention to all possible disasters.

The sub-committees include rescue, clothing, shelter, medical aid, transportation, food, registration, finance, and survey committees. The duties of most of these committees are self-explanatory. The important ones to start with, of course, are those dealing with survey, rescue, and medical aid. The Survey Committee should gather information as to the probable place of disaster and local facilities for meeting it. The Committee on Rescue should be prepared to go into action at any time, day or night, to take care of the injured and proceed with other work of rescue, be it flood, fire, earthquake, or storm. The Medical Aid Committee is of course somewhat along the same line, to mobilize doctors and nurses when necessary.

This, in general, is the Red Cross Major Disaster Relief Plan and it is described in fuller detail in their bulletin which they would be glad to send to anyone who is interested. From Mr. Somerville's report it is evident that the bulk of rescue work in case of disasters is a job for engineers and engineering methods. I believe that all engineers in our Division of Highways, as well as all County superintendents, should be familiar with the work of the Red Cross and its method of procedure, so that in case of any disaster in their communities they might proceed with the necessary aid without any lost motion.